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Seal Damage to Salmon Fisheries

By
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and
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January, 1965

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Seal Damage to Salmon Fisheries

INTRODUCTION AND MATERIAL

The damage caused by seals to salmon fisheries on the Northumberland and Berwickshire coasts was studied by Lockie (1959) from the summer of 1956 to September 1958. From a study of factual reports by fishermen Lockie arrived at certain conclusions and estimated the extent of the losses to the fisheries. The nature of the damage experienced along the Scottish coast as a whole was described by Rae (1960), while Shearer (1962) examined the damage to nets in greater detail. Since the publication of these papers more information on this subject, from various sources, has become available for examination.

In April 1959, books of log forms for recording damage caused by seals were sent to salmon-fishing firms operating fixed-nets (see below) at points on the east coast from Goswick (Northumberland) to Berriedale (Caithness) and to one firm fishing on the west coast, on the island of Skye. A copy of the form circulated is reproduced in Appendix I. The majority of the firms asked to supply information readily agreed to do so and completed forms were returned regularly throughout the remaining part of the 1959 season.

As a number of netsmen reported that the damage to nets and salmon by seals was greater during the early part of the season the same firms were asked to make returns from the opening of the 1960 fishing season. The response was again most encouraging, and although the netsmen were asked to keep records only for the part of the season not covered in 1959, many of them did so throughout the season and some kindly arranged for more of their stations to keep records.

As the weather conditions during the early part of the 1960 fishing season brought salmon fishing virtually to a standstill at most netting stations, there was still a lack of information on the damage to nets during this period, and the netting firms which had completed forms were again asked to keep records in 1961, particularly during the early part of the year. In 1962 and 1963 this request was repeated, and in addition the majority of the stations returning completed logs were visited so that the local problems could be discussed with the netsmen.

The types of nets employed at each station included in the analysis of net-damage and the periods over which records were kept are set out in Table I. The positions of these stations and of others referred to in the text are shown in Figure 1.

A preliminary analysis of some of these records was carried out by Mountford and Smith (1963).

Logs kept by fishermen at two net-and-coble stations in the mouth of the River Tweed from 1956 to 1958 and in 1960 and 1961 have also been studied, and notes on the occurrence of seal-damaged, though still marketable, salmon in catches from different sources have been analysed.

This investigation has been possible only through the co-operation of tacksmen, netsmen and fishermen throughout the country, and accordingly the authors wish to thank all who contributed information of one kind or another. They also wish to express their appreciation of the constructive criticism and advice offered during the preparation of this paper by Dr C. E. Lucas and Mr K. A. Pyefinch and of the help given in a variety of ways by members of the laboratory staffs at Aberdeen and Pitlochry.

TABLE I

DETAILS OF NETTING STATIONS INCLUDED IN THE ANALYSIS OF NET DAMAGE

Name	*Type(s) of net used*	*Period for which records available*				
		1959	*1960*	*1961*	*1962*	*1963*
Cheswick[a]	Bag, Fly, Jumper	20/4–22/8	22/2–27/8	20/2–22/7	15/2–14/9	18/2–31/8
Goswick[a]	Bag, Fly, Jumper	20/4–22/8	22/2–23/7	15/2–22/7		
Boddin	Bag, Fly	6/4–29/8	16/2–31/8	14/2–31/8	16/2–31/8	4/3–24/8
Rossie	Fly	—	—	16/2–31/8	16/2– 1/9	4/3–24/8
Watermouth	Bag	6/4– 9/8	15/2– 1/9	16/2–31/8	16/2–31/8	4/3–24/8
Charleton	Bag	—	24/2–31/8	16/2–31/8	16/2–31/8	4/3–24/8
Woodston	Fly	—	18/2–31/8	16/2–31/8	16/2–31/8	4/3–24/8
Woodston	Bag	—	18/2–31/8	16/2–31/8	16/2–31/8	4/3–24/8
Rockhall	Bag	6/4–22/8	16/2–31/8	16/2–31/8	16/2–31/8	4/3–24/8
Johnshaven	Bag	—	16/2–27/8	16/2–26/8	16/2–31/8	4/3–24/8
Cruden Bay	Bag	13/4– 5/9	3/3– 9/9	3/3– 9/9	27/2– 1/9	6/3– 7/9
Ugie-Buchanhaven	Bag	11/5– 5/9	9/6– 8/9	2/5– 9/9	5/6– 9/9	4/6– 7/9
Pennan	Bag	13/4–27/6	25/1–21/5	11/2–13/5	—	—
Gardenstown	Bag	13/4–27/6	15/2– 9/7	11/2–15/4	19/2–14/7	7/3–17/8
Portgordon	Bag, Fly	13/4–15/8	29/2–30/4	—	18/6–18/8	—
Nairn	Bag, Fly	—	8/3–13/8	6/3–24/8	5/3–23/8	5/3–24/8
East Delnies	Bag, Fly	—	23/2–13/8	13/3–24/8	5/3–23/8	5/3–24/8
West Delnies	Bag, Fly	—	23/2–13/8	6/3–24/8	5/3–23/8	18/3–24/8
Gallowhill	Bag	6/4–30/5	25/4–13/8	8/5–18/8	—	—
Cromarty	Bag	6/4–30/5	25/4–13/8	25/4–19/8	1/5–22/8	24/4–21/8
Berriedale	Bag	13/4–23/5	—	12/3– 1/4	5/3–26/5	—
Melvich	Bag	—	16/5– 6/8	—	—	—
Brochel Castle	Bag	7/5–25/7	2/5–19/8	22/5–29/7	2/7– 6/8	—

— indicates no records.

[a] The stations at Goswick and Cheswick were fished as a single station in 1962 and 1963.

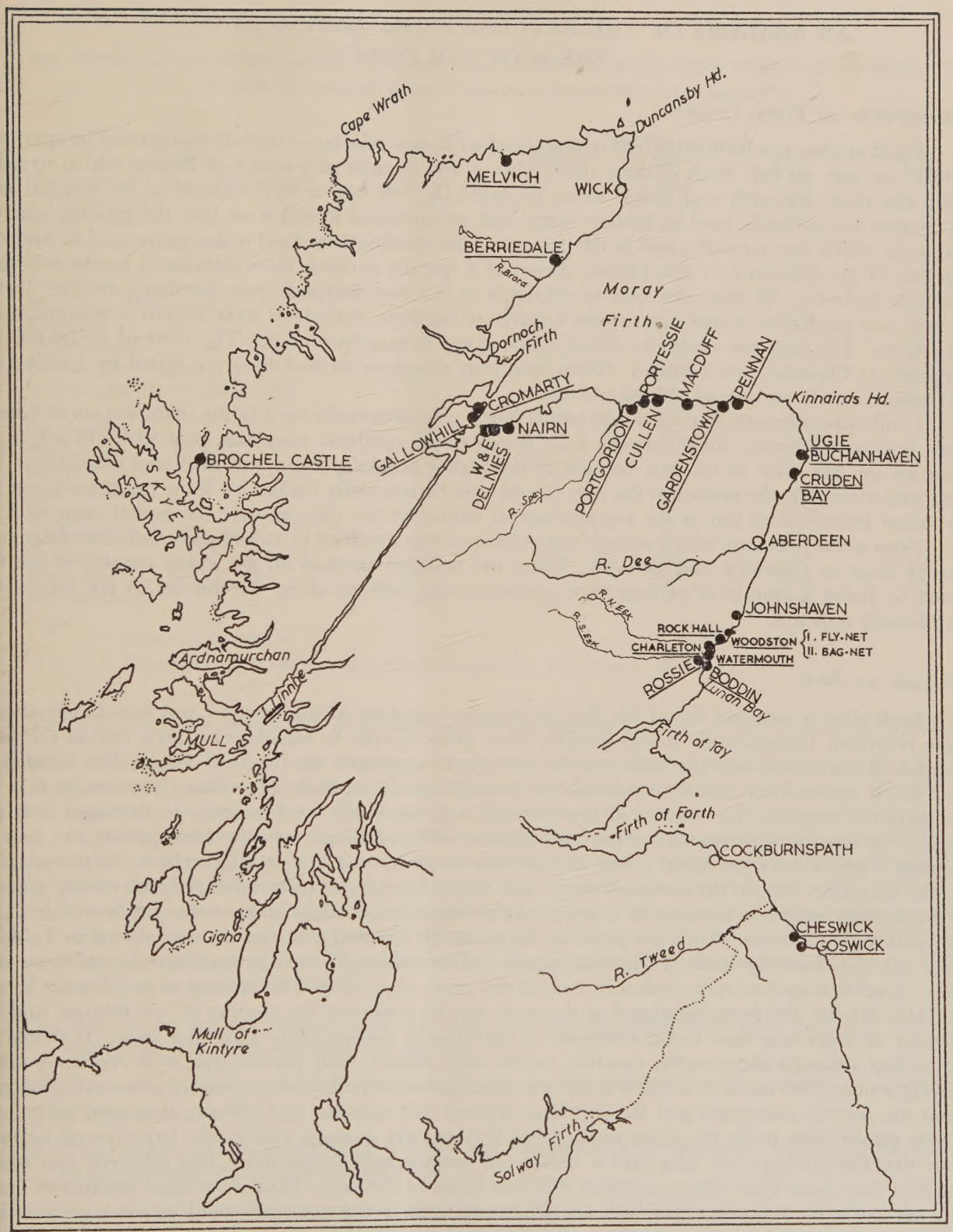

FIG. 1. Showing location of fixed-net salmon-fishing stations from which returns were made (indicated by black circles). Stations included in the analysis of net damage are underlined.

AN ANALYSIS OF THE RETURNS FROM FISHING STATIONS ON THE SCOTTISH COAST

Description of Fixed Engines

Fixed engines can be divided into bag-nets and stake-nets; the latter include fly-nets and jumper-nets which are very similar. Each of these three types of net consists of a leader of netting which stretche from the shore seawards and which serves to guide the fish into a trap situated at its seaward end Stake-nets are normally used in shallow water and are attached to stakes set into the ground, wherea bag-nets, which are normally used in deeper water, are floating nets fixed to buoys moored to anchors Because of the difference in attachment, the set of a bag-net is much more influenced by the tide than that of a stake-net. All these nets may be set singly or in a line outwards from the shore, and the fleet o nets at any particular station may consist entirely of bag-nets, entirely of stake-nets or a mixture of th two types. The nets are normally fished twice every twenty-four hours. The method of fishing th bag-nets at Cheswick and Goswick differs from that elsewhere in that they are fished by hauling th net ashore by tractor instead of from a coble.

Until approximately five years ago cotton twine was universally used in the manufacture of salmon nets, but more recently, some netsmen have begun to use synthetic materials, principally Courlene, a least for the fish court of the net. Because of the higher breaking strain and increased elasticity of th synthetic materials, the meshes of the nets should now be less easily broken by seals, but there is not ye any clear indication of this in the average annual values for net damage over the period 1959–63.

None of the nets from which records were obtained was modified in any way to combat seal damage except those at Cheswick and Goswick. There the netsmen blocked off the sharp corners of the fish court by fixing a curtain of netting from approximately halfway along the inscales to the side of th net directly opposite.

Damage to Nets

Each time a netsman fished his fleet of nets the numbers of undamaged and seal-damaged net were recorded. Consequently it was possible from these records to calculate for each station the tota number of nets fished and the total number damaged every time the fleet was fished. The number o nets fished varied from station to station and, in some instances, from one visit to another, so that fo comparative purposes the amount of net damage is given as the total number of damaged nets pe period expressed as a percentage of the total number of 'net-fishings' over the same period, i.e., nets × fishings. Thus, if a station fished a fleet of 6 nets for a whole week during which eleven visits were paid by the fishermen and, in the course of these visits 6 nets were found to be damaged, the weekly amoun of net-damage would be 6 out of 66 or 9·1% of the 'net-fishings'. This weekly value has been calculated for each station and the results are given in Appendix II. Similarly, the results reproduced in Table I were calculated on the basis of the total number of 'net-fishings' and the total number of times net were found damaged at each station in each of the years 1959–1963. The amount of net-damage show in Table III has also been calculated in the same way by summing the number of 'net-fishings' and th number of times nets were found damaged in each month during 1960, 1961 and 1962. (It should b noted that although these yearly, monthly, weekly and, indeed, daily percentages, as so reckoned, are o the same order, the number of times a net was damaged necessarily differs greatly, as one would expec from the periods concerned and the fact that any one net may be, and often is, damaged frequently There would seem to be no direct relationship between net damage and catch. Experienced netsmen state that the catch per net in a fleet of nets is not uniform and, furthermore, that different nets within the fleet may have their biggest catch at different times of the year. Thus if the most productive net a any particular time was damaged by seals, the loss of catch to the netsmen would be much greater than would be apparent from the overall figure of the amount of net-damage at that station. Accordingly it has not been possible to calculate a figure for the loss of catch at any station from the figures of th amount of net damage at that station.

TABLE II

THE ANNUAL AMOUNT OF NET DAMAGE EXPRESSED AS A PERCENTAGE OF THE TOTAL NUMBER OF NET-FISHINGS (I.E. NETS × FISHINGS) DURING THE FIVE FISHING SEASONS 1959–1963

Station	*Percentage damage*				
	1959	*1960*	*1961*	*1962*	*1963*
Cheswick and Goswick[a] (mixed)	4·0	3·1	2·7	0·6	1·5
Boddin (mixed)	5·8	6·8	7·7	4·3	6·0
Rossie (Fly-nets)	—	—	0	0	+
Watermouth (Bag-nets)	4·6	5·6	3·9	4·2	0·1
Charleton (,,)	—	2·0	3·2	2·1	0·3
Woodston (Fly-nets)	—	0	0	0	0
Woodston (Bag-nets)	—	1·2	0·5	0·4	0·1
Rockhall (,,)	2·2	3·0	3·1	4·1	2·1
Johnshaven(,,)	—	3·0	4·4	1·4	0·5
Cruden Bay(,,)	35·8	18·7	12·7	14·0	29·1
Ugie-Buchanhaven (Bag-nets)	37·8	10·3	9·0	25·4	42·0
Pennan (,,)	15·3	20·1	12·8	—	—
Gardenstown (,,)	2·2	5·3	6·4	2·4	1·4
Portgordon (mixed)	36·2	57·4	—	33·0	—
Nairn (,,)	—	2·1	2·3	2·1	1·7
East Delnies (,,)	—	11·0	9·5	14·0	6·7
West Delnies (,,)	—	10·8	9·2	7·5	5·0
Gallowhill (Bag-nets)	3·5	5·4	3·2	—	—
Cromarty (,,)	6·5	5·6	7·4	2·7	0
Berriedale (,,)	32·2	—	30·6	36·4	—
Brochel Castle (,,)	10·8	14·1	11·3	10·0	—

— indicates no record.

[a] Calculated as a combined station throughout, see notes to Table I.

Table II shows the percentage of net damage for the period 1959–63. Points of interest include:

(*a*) Virtually no damage was recorded at the two stations fishing stake-nets only (Rossie and Woodston), and at the stations fishing a mixture of stake- and bag-nets most, if not all, the damage was sustained by the bag-nets. The major exceptions to this generalisation are at Cheswick and Goswick, where the stake-nets sustained some damage. The reason for this is not known, but proximity to the breeding grounds on the Farnes may have had some effect. The most obvious difference between bag-nets and stake-nets is shown by the two stations at Woodston, where the fly-net station sustained no damage, whereas the bag-net station sustained some damage, though the yearly averages were generally lower than those of other bag-net stations in Montrose Bay. Thus, damage is almost confined to stations fishing bag-nets, either wholly or as part of their fleet.

(*b*) Most of the bag-net stations show less than 20% damage, two-thirds show less than 10% and nearly one-half show less than 5% damage.

(*c*) There would seem to be little evidence of any marked trend in the percentage of net damage from year to year.

(*d*) There is no obvious relationship between net damage and the proximity of the netting station to the breeding grounds of the grey seal.

The reason why stake-nets are rarely damaged is not known. As seals have been caught in stake-nets, it is clearly possible for seals to enter them, so that one possible explanation is that the method of rigging of these nets allows a seal to enter the fish court through the door and leave again by the same route, which may be much more difficult in a bag-net.

TABLE III

THE MONTHLY AMOUNT OF NET DAMAGE DURING THE PERIOD 1960–1962 EXPRESSED AS A PERCENTAGE OF THE TOTAL NUMBER OF NETS FISHED EACH MONTH DURING THAT PERIOD

Station	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*
Cheswick and Goswick[a] (mixed)	3·2	3·9	2·4	2·2	1·4	1·4	0·4[d]	0[b]
Boddin (mixed)	12·7	16·2	11·4	9·4	1·6	2·6	0·9	—
Rossie (Fly-nets)	0[c]	0[c]	0[c]	0[c]	0[c]	0[c]	0[c]	—
Watermouth (Bag-nets)	12·5	11·2	9·2	10·4	4·9	2·0	0·03	—
Charleton („)	8·7	11·2	3·7	6·4	1·2	0·9	0	—
Woodston (Fly-nets)	0[c]	0[c]	0	0	0	0	0	—
Woodston (Bag-nets)	5·7	1·4	4·7	0·5	0·6	0	0	—
Rockhall („)	14·9	10·2	6·0	3·5	1·1	0·2	0	—
Johnshaven(„)	5·8	9·2	9·0	2·0	0·6	0	0·7	—
Cruden Bay(„)	0[b]	16·0	21·0	21·0	11·8	16·8	10·8	5·2[e]
Ugie-Buchanhaven (Bag-nets)	—	—	—	2·9[f]	3·2	24·9	14·6	20·0
Pennan („)	19·2[c]	37·4[e]	12·4	2·6[e]	—	—	—	—
Gardenstown („)	5·2	15·0	2·4	1·3[d]	0·5[d]	0[d]	—	—
Portgordon (mixed)	—	73·6[g]	49·0[g]	—	45·7[b]	24·2[b]	33·3[b]	—
Nairn („)	—	6·0	4·7	3·7	0·3	0	0·3	—
East Delnies („)	0[g]	20·8	21·6	14·3	9·0	5·6	7·6	—
West Delnies („)	20·0[g]	25·0	16·8	9·7	5·1	2·5	4·9	—
Gallowhill (Bag-nets)	—	—	0[g]	3·5[e]	4·2[e]	3·8[e]	3·9[e]	—
Cromarty („)	—	—	5·8	6·4	4·7	3·8	3·5	—
Berriedale („)	—	22·6[c]	53·6[c]	31·0[b]	—	—	—	—
Brochel Castle („)	—	—	—	11·5[e]	19·5[e]	13·7	10·1[d]	—

— indicates no record.

[a] Calculated as a combined station throughout.

[b] 1962 only.

[c] 1961 and 1962 only.

[d] 1960 and 1962 only

[e] 1960 and 1961 only.

[f] 1961 only.

[g] 1960 only.

Table III, which gives the percentage net damage, at monthly intervals, for 1960–62 (the records for 1959 have been omitted from this table because of the lack of records during the spring of that year) adds more detail to the picture given by the results in Table II. In particular, it would seem that three patterns of seasonal damage can be recognised:

(*a*) Stations at which the proportion of nets damaged is small, but persists through the season (e.g. Cheswick and Goswick, Cromarty, and perhaps Gallowhill).

(*b*) Stations at which damage is heavier during the early part of the season but decreases markedly later (e.g. Boddin, Watermouth, Charleton, Woodston [bag-nets], Rockhall, Johnshaven, Gardenstown, Nairn, East Delnies and West Delnies).

(*c*) Stations at which damage is heavy for most of the season (e.g. Cruden Bay, Ugie-Buchanhaven, Portgordon and Brochel Castle).

Thus, at about half the stations from which records were obtained, net damage is seasonal in its incidence. This indicates one way in which the annual values given in Table II may be misleading, namely, that if a station is one which takes most of its catch during the early months of the season, a high incidence of net damage over this period will have more effect on the catches than is suggested by the annual average figure and vice versa.

Seals Seen in the Vicinity of the Nets

Whilst some of the information given in the returns, for example the number of damaged nets, is unquestionably precise, other items are less informative; thus the numbers of seals seen do not necessarily represent the true numbers present in the vicinity of the nets.

Although it is understood that fishermen have tried to make allowances for one seal being seen more than once on any one visit to the nets, this cannot be certain. Thus, at the Goswick station in 1959, 151 sightings were made in 18 weeks, the number varying from 0 to 7 on any one visit. While these numbers are believed to represent the total numbers of seals seen on any one day, they are likely to be less correct as regards the numbers actually visiting the nets on each day and the estimate may well be low; but first calculations will be based on the conservative assumption that no more seals were present. On many occasions no seals were seen at the nets and most of the sightings referred to one animal. On the extreme assumption that two or more sightings of seals on a single fishing visit by the fishermen were of the same animal, an alternative and even more conservative calculation has been based on the premise that only one seal was present on each fishing occasion when one or more sightings of seals were made. The latter calculation will be indicated by the value in brackets.

TABLE IV

SUMMARIES OF SALMON FISHING STATION RETURNS ON SCOTTISH EAST COAST, 1959–1963

(Figures in brackets represent numbers of seals, assuming that only one was present when two or more were reported as seen)

1959

Station	*Period of observations week beginning*	*No. of weeks*	*No. of seal sightings*	*No. of seals seen with salmon*	*No. of salmon heads etc.*	*Average No. of seals per working week*
Goswick	20/4 – 22/8	18	151(88)	1	14	8·4(4·9)
Cheswick	20/4 – 22/8	18	183(93)	0	6	10·2(5·2)
Boddin	16/2 – 29/8	27	41(34)	16	9	1·5(1·3)
Watermouth	6/4 – 29/8	21	195(112)	39	95	9·3(5·3)
Charleton	—	—	—	—	—	—
Woodston (Fly-nets)	1/6 – 27/6	4	9(9)	4	0	2·3(2·3)
Rockhall	6/4 – 22/8	18	60(46)	7	0	3·3(2·6)
Johnshaven	—	—	—	—	—	—
Woodston (Bag-nets)	—	—	—	—	—	—
Rossie	—	—	—	—	—	—
Cruden Bay	13/4 – 5/9	21	192(101)	4	1	9·1(4·8)
Ugie	11/5 – 5/9	17	87(64)	9	0	5·1(3·8)
Gardenstown	13/4 – 27/6	11	11(9)	0	0	1·0(0·8)
Pennan	13/4 – 27/6	11	19(17)	0	2	1·6(1·5)
Macduff	20/4 – 9/5	3	17(15)	5	5	5·7(5·0)
Cullen	6/4 – 23/5	7	17(13)	5	7	2·4(1·9)
Portgordon	13/4 – 15/8	18	325(191)	38	56	18·1(10·6)
Portessie	13/4 – 20/6	9	40(21)	1	7	4·4(2·3)
Nairn	—	—	—	—	—	—
East Delnies	—	—	—	—	—	—
West Delnies	—	—	—	—	—	—
Gallowhill	6/4 – 30/5	8	35(32)	4	1	4·4(4·0)
Cromarty	6/4 – 25/7	7	29(25)	3	8	4·1(3·6)
Berriedale	13/4 – 23/5	6	93(37)	4	7	15·5(6·2)
All Stations		224	1504(907)	140	218	6·7(4·0)

TABLE IV—*continued*

Station	*Period of observations week beginning*	*No. of weeks*	*No. of seal sightings*	*No. of seals seen with salmon*	*No. of salmon heads etc.*	*Average No. of seals per working week*
			1960			
Goswick	22/2 – 23/7	22	88(61)	0	0	4·0(2·8)
Cheswick	22/2 – 3/9	23	136(75)	0	0	5·9(3·3)
Boddin	15/2 – 3/9	29	44(39)	11	1	1·3(1·3)
Watermouth	15/2 – 3/9	29	210(128)	42	135	7·2(4·4)
Charleton	15/2 – 3/9	29	49(45)	5	0	1·7(1·6)
Woodston (Fly-nets)	15/2 – 3/9	29	44(44)	33	21	1·4(1·4)
Rockhall	15/2 – 3/9	29	108(79)	3	4	3·7(2·7)
Johnshaven	15/2 – 27/8	28	57(55)	0	2	2·0(2·0)
Woodston (Bag-nets)	15/2 – 3/9	28	20(20)	2	8	0·7(0·7)
Rossie	15/2 – 3/9	—	—	—	—	—
Cruden Bay	3/3 – 8/9	28	185(96)	1	2	6·6(3·4)
Ugie	6/6 – 7/9	14	19(15)	0	0	1·4(1·1)
Gardenstown	15/2 – 9/7	21	57(46)	15	4	2·7(2·2)
Pennan	25/1 – 21/5	16	40(37)	0	0	2·4(2·3)
Macduff	—	—	—	—	—	—
Cullen	—	—	—	—	—	—
Portgordon	29/2 – 30/4	9	125(92)	9	36	13·9(10·2)
Portessie	—	—	—	—	—	—
Nairn	7/3 – 13/8	22	14(13)	2	12	0·6(0·6)
East Delnies	22/2 – 13/8	24	38(37)	20	26	1·6(1·5)
West Delnies	22/2 – 13/8	25	5(5)	0	1	0·2(0·2)
Gallowhill	25/4 – 13/8	16	23(21)	3	14	1·4(1·3)
Cromarty	25/4 – 13/8	16	37(30)	1	18	2·3(1·9)
Berriedale	—	—	—	—	—	—
All Stations		437	1299(938)	147	284	3·0(2·1)
			1961			
Goswick	13/2 – 22/7	23	119(75)	0	0	5·2(3·3)
Cheswick	20/2 – 22/7	20	242(128)	0	0	12·1(6·4)
Boddin	14/2 – 31/8	29	68(55)	14	5	2·3(1·9)
Watermouth	14/2 – 31/8	29	160(100)	29	83	5·5(3·4)
Charleton	14/2 – 31/8	29	94(79)	25	14	3·2(2·7)
Woodston (Fly-nets)	14/2 – 31/8	29	99(52)	95	5	3·4(1·8)
Rockhall	14/2 – 31/8	29	80(66)	6	0	2·8(2·3)
Johnshaven	14/2 – 31/8	29	104(94)	27	0	3·5(3·2)
Woodston (Bag-nets)	14/2 – 31/8	29	19(17)	1	5	0·7(0·6)
Rossie	14/2 – 31/8	29	12(12)	2	1	0·4(0·4)
Cruden Bay	6/3 – 3/9	26	133(72)	0	0	5·1(2·8)
Ugie	1/5 – 9/9	19	27(21)	2	0	1·4(1·1)
Gardenstown	13/2 – 15/4	9	21(20)	4	3	2·3(2·2)
Pennan	13/2 – 13/5	13	26(24)	0	0	2·0(1·8)
Macduff	—	—	—	—	—	—
Cullen	—	—	—	—	—	—
Portgordon	—	—	—	—	—	—
Portessie	—	—	—	—	—	—
Nairn	6/3 – 26/8	25	19(13)	5	4	0·8(0·5)
East Delnies	13/3 – 26/8	24	27(23)	0	1	1·1(1·0)
West Delnies	6/3 – 26/8	25	49(37)	5	19	2·0(1·5)
Gallowhill	8/5 – 19/8	15	24(24)	0	1	1·6(1·6)
Cromarty	24/4 – 19/8	17	49(42)	1	5	2·9(2·5)
Berriedale	13/3 – 15/7	11	86(55)	0	1	7·8(5·0)
All Stations		459	1458(1009)	216	147	3·2(2·2)

TABLE IV—*continued*

1962

Station	*Period of observations week beginning*	*No. of weeks*	*No. of seal sightings*	*No. of seals seen with salmon*	*No. of salmon heads etc.*	*Average No. of seals per working week*
Goswick Cheswick	19/2 – 14/9	30	294(147)	0	0	9·8(4·9)
Boddin	16/2 – 1/9	29	22(19)	3	2	0·8(0·7)
Watermouth	19/2 – 1/9	28	244(132)	53	88	8·0(4·7)
Charleton	19/2 – 1/9	28	28(27)	2	6	1·0(1·0)
Woodston (Fly-nets)	16/2 – 1/9	29	83(61)	60	14	2·9(2·1)
Rockhall	16/2 – 1/9	29	98(82)	13	2	3·4(2·8)
Johnshaven	19/2 – 1/9	28	15(14)	0	0	0·5(0·5)
Woodston (Bag-nets)	16/2 – 1/9	26	11(11)	1	0	0·4(0·4)
Rossie	16/2 – 1/9	29	6(6)	0	0	0·2(0·2)
Cruden Bay	26/2 – 1/9	24	133(74)	0	0	5·3(3·1)
Ugie	4/6 – 8/9	14	67(42)	6	0	4·8(3·0)
Gardenstown	19/2 – 14/7	21	20(17)	7	5	1·0(0·8)
Pennan	—	—	—	—	—	—
Macduff	—	—	—	—	—	—
Cullen	—	—	—	—	—	—
Portgordon	18/6 – 18/8	8	133(55)	49	26	16·6(6·9)
Portessie	—	—	—	—	—	—
Nairn	5/3 – 25/8	25	24(19)	2	1	1·0(0·8)
East Delnies	5/3 – 25/8	25	34(33)	0	0	1·4(1·3)
West Delnies	5/3 – 25/8	24	22(22)	0	1	0·9(0·9)
Gallowhill	—	—	—	—	—	—
Cromarty	30/4 – 25/8	17	38(28)	0	3	2·2(1·6)
Berriedale	5/3 – 26/5	12	192(56)	0	0	16·0(4·7)
All Stations		423	1444(845)	196	148	3·4(2·0)

1963

Station	*Period of observations week beginning*	*No. of weeks*	*No. of seal sightings*	*No. of seals seen with salmon*	*No. of salmon heads etc.*	*Average No. of seals per working week*
Goswick Cheswick	18/2 – 31/8	28	364(145)	4	17	13·0(5·2)
Boddin	4/3 – 24/8	25	24(22)	6	8	1·0(0·9)
Watermouth	25/3 – 24/8	22	30(26)	1	13	1·4(1·2)
Charleton	25/3 – 24/8	20	25(20)	0	1	1·3(1·0)
Woodston (Fly-nets)	4/3 – 24/8	23	34(34)	36	44	1·5(1·5)
Rockhall	4/3 – 24/8	24	95(78)	8	0	4·0(3·3)
Johnshaven	4/3 – 24/8	20	8(8)	0	0	0·4(0·4)
Woodston (Bag-nets)	22/3 – 24/8	17	3(3)	0	0	0·2(0·2)
Rossie	4/3 – 24/8	25	12(11)	0	0	0·5(0·4)
Cruden Bay	6/3 – 7/9	27	285(130)	0	0	10·6(4·8)
Ugie	4/6 – 7/9	14	116(58)	3	0	8·3(4·1)
Gardenstown	7/3 – 17/8	24	7(7)	1	2	0·3(0·3)
Pennan	—	—	—	—	—	—
Macduff	—	—	—	—	—	—
Cullen	—	—	—	—	—	—
Portgordon	—	—	—	—	—	—
Portessie	—	—	—	—	—	—
Nairn	5/3 – 24/8	25	6(6)	0	0	0·2(0·2)
East Delnies	5/3 – 24/8	25	8(8)	0	2	0·3(0·3)
West Delnies	18/3 – 24/8	23	3(3)	0	0	0·1(0·1)
Gallowhill	—	—	—	—	—	—
Cromarty	24/4 – 21/8	18	24(20)	0	2	1·3(1·1)
Berriedale	—	—	—	—	—	—
All Stations		360	1044(579)	59	89	2·9(1·6)

It should be explained that where two or more seals were observed by the fisherman *simultaneously* or where a dead seal was found in the nets at the same time as a live seal was seen near the nets, these records have been regarded as two or more seals.

The analysis of this information has been confined to returns from the east coast of Scotland (see Table IV). A total of 91 sets of records was received from 24 stations, during the period 1959–63, and of these 65 covered 75% or more of the fishing *season*. It should be explained, however, that fishing is not carried on at all the stations throughout the entire season, so that the number of stations at which observations were recorded over three-quarters of the actual fishing *period* may well be greater than 65. Fifty-eight returns included coverage of the opening weeks of the season from mid-February to mid-March, and 71 the closing weeks from mid-August to the beginning of September. Observations were made over a total of 1903 net-fishing-weeks during the five years.

The records of seals given in the returns cover varying periods of observation, details of which are not always available. Salmon fixed-nets are normally fished twice daily, bag-nets by coble about 6 a.m. and 2 p.m., and fly- and jumper-nets from the beach in accordance with the tide. Normally this takes only a short time so that the time spent in the vicinity of each individual netting station is generally short and rarely amounts to four hours each day. It is convenient, however, to regard four hours as representing the observation time at the majority of the stations, although this must usually be an over-estimate since the fishermen cannot keep a continuous look-out for seals while attending to their nets. At certain stations overlooked by a salmon bothy or a fisherman's house, observations may be maintained over a longer period, but even in such places a watch on the nets cannot be kept up continuously, and it is doubtful if the effective observation time exceeds eight hours per day. In either circumstance, fewer (and perhaps many fewer) seals must be 'seen' than could be expected to be 'visible'.

The likelihood that fewer seals were seen than were present is also borne out by the numerous references in the returns to seal damage to nets and/or fish on days on which no seals were observed in the vicinity of the nets, although these indications have not been brought into the calculations. For example, at the East Delnies Station, Nairn, in 1962, seal damage to nets was experienced on 45 days on which no seals were seen on the station. During the fishing season of 137 days at this station seals were seen on 34 occasions on 33 days, so that altogether they may have been present on as many as 78 days. This would more than double the estimated average number of seal visits to the nets at East Delnies per week, but it must be remembered that net damage caused on a previous visit may occasionally be overlooked by the fishermen. Similarly, at the Boddin Station in Angus, nets were torn on 40 days on which no seals were seen. Seals were observed on 22 different occasions on 17 days at this station, so that the total number of visits by these animals may have been at least 57; that is, nearly three times the observed number. Over the eighteen stations making returns in 1962, nets were damaged on 171 occasions when no seals were reported. Consequently the number of seal visits in 1962, 1444, should possibly be increased by 171 to 1615, and the average number of visits per week from 3·4 to 3·8. (Alternatively, on the assumption that only one seal was present in the vicinity of the nets, when two or more were reported, the total would be increased from 845 to 1016.)

Seal-clawed salmon, which are still marketable (to be distinguished from mutilated salmon, which are unmarketable) were also recorded on many days on which no seals were observed. At the Watermouth Station in Angus, seal-clawed salmon were reported on 34 days on which no seal was seen, and at the eighteen stations in 1962 clawed salmon were recorded under the same circumstances on 111 occasions. Although some of these fish may have been wounded before reaching the stations where they were caught, the evidence again suggests that the numbers of seals in the vicinity of the stations are greater than the numbers observed.

The failure of the fishermen to observe seals may be due to their preoccupation with fishing operations, to poor visibility in foggy weather or during the night and early morning, or simply to the departure of the seals before the arrival of the fishermen.

Seal behaviour

Before considering the analysis of the data on seal appearances it is appropriate to summarise briefly some general observations by the netsmen on seal behaviour. These observations, though recorded

TABLE V

THE NUMBER OF OCCASIONS THE NETS WERE FISHED (F) AND THE NUMBER OF SEALS SEEN (S) IN EACH HALF-HOUR OF THE DAY AT THE GOSWICK AND CHESWICK FISHING STATIONS

	Goswick						*Cheswick*						*Goswick and Cheswick*			
	1959		*1960*		*1961*		*1959*		*1960*		*1961*		*1962*		*1963*	
	F	*S*	*F*	*S*	*F*	*S*	*F*	*S*	*F*	*S*	*F*	*S*	*F*	*S*	*F*	*S*
00·00	1	–	4	3	3	3	3	1	4	1	5	8	5	–	2	–
00·30	2	1	3	–	3	–	1	–	3	–	1	–	3	–	2	–
01·00	3	1	2	–	1	–	3	2	3	–	3	–	5	–	7	–
01·30	2	–	4	–	5	–	2	2	5	3	1	2	5	–	5	–
02·00	3	2	2	–	–	–	4	1	2	–	5	6	5	1	7	–
02·30	3	1	3	–	7	–	1	–	5	1	2	2	2	–	4	–
03·00	–	–	3	–	1	–	4	2	5	1	5	1	5	1	8	–
03·30	5	7	4	–	5	–	3	2	3	–	2	1	4	–	4	3
04·00	1	–	3	–	2	1	3	1	6	2	3	1	3	–	6	4
04·30	4	4	5	–	7	–	2	–	3	1	6	7	6	1	5	2
05·00	1	–	4	–	2	–	4	2	4	3	2	–	4	6	6	5
05·30	6	5	3	4	6	–	3	3	4	1	4	1	7	3	5	4
06·00	1	–	6	3	4	2	5	6	4	–	3	1	5	6	4	1
06·30	4	1	3	–	7	1	2	1	5	3	3	5	6	3	3	3
07·00	3	1	6	1	5	2	8	3	4	–	5	4	8	11	6	6
07·30	5	5	4	1	5	2	4	3	7	3	2	4	6	6	5	10
08·00	5	2	5	1	6	4	5	1	3	–	8	6	8	12	8	7
08·30	3	2	5	4	7	5	5	2	5	2	5	5	7	8	5	11
09·00	7	7	3	1	5	6	6	9	7	2	3	5	7	8	10	20
09·30	4	3	6	7	6	4	4	3	4	3	5	9	8	11	3	9
10·00	6	8	2	–	4	4	5	8	6	3	6	11	8	13	11	23
10·30	2	1	3	4	4	1	4	6	4	1	5	3	8	14	4	7
11·00	7	6	3	1	6	7	5	8	2	–	7	13	4	8	6	8
11·30	4	4	4	2	1	–	3	3	4	–	1	–	8	14	6	15
12·00	2	3	1	–	4	3	–	–	3	6	5	5	8	12	3	5
12·30	1	1	2	3	–	–	3	4	5	4	1	–	4	8	7	19
13·00	4	6	5	2	5	6	3	1	3	3	1	–	5	5	4	14
13·30	4	2	1	–	–	–	4	5	3	1	4	6	4	7	7	29
14·00	2	3	6	5	9	10	1	–	4	5	3	3	5	7	4	5
14·30	1	1	2	2	–	–	3	7	3	3	5	8	3	4	8	20
15·00	5	2	4	4	5	8	5	–	7	3	3	8	4	6	4	5
15·30	1	2	3	3	2	1	2	2	3	4	2	3	4	5	7	20
16·00	5	6	4	4	7	6	3	5	4	1	5	11	6	10	5	7
16·30	1	–	4	4	2	–	2	4	4	4	3	5	4	7	6	23
17·00	6	10	3	6	7	7	4	7	4	4	6	11	7	11	5	8
17·30	1	1	7	6	4	3	3	6	3	2	2	2	6	7	4	7
18·00	4	4	3	4	8	12	4	11	7	13	4	6	6	7	4	3
18·30	3	9	5	2	5	3	3	4	2	–	5	11	7	13	6	9
19·00	5	8	4	2	4	2	3	6	8	10	3	5	7	9	6	9
19·30	5	7	5	2	4	3	4	4	2	2	4	8	8	10	7	8
20·00	3	5	4	3	5	5	4	2	5	10	6	4	7	12	5	5
20·30	6	7	5	–	5	2	6	10	7	7	2	6	7	12	10	17
21·00	3	5	5	2	7	3	4	9	4	3	7	11	7	3	4	4
21·30	6	7	2	–	3	3	6	13	5	5	4	9	6	3	10	1
22·00	4	1	4	2	7	–	3	8	3	5	4	4	8	8	4	–
22·30	5	–	2	–	3	–	2	1	3	4	7	8	5	–	7	–
23·00	3	–	2	–	2	–	3	2	3	4	2	4	7	1	4	5
23·30	3	–	2	–	4	–	5	3	3	3	5	9	6	–	5	3

independently by fishermen on different parts of the coast, are remarkable for their general similarity.

(i) Seals are frequently active on the fishing grounds from January onwards, i.e. before the commencement of the salmon fishing season. This is confirmed by reports from lobster, white-fish and herring fishermen.

(ii) Seals may be active round the nets at any time of the day at one time or another, although not necessarily throughout the 24 hours. This feature of seal behaviour is evident from information derived from various sources, but is perhaps most clearly demonstrated by the returns from the stations at Goswick and Cheswick in Northumberland. Fishing at these stations is carried out strictly according to the state of the tide and consequently varies throughout the 24 hours. In Table V the fishermen's reports of seals seen have been summarised for each year together with the number of occasions on which the nets were fished in each half-hour period of the day throughout each fishing season. It is evident that seals may be active round the nets at all times, although possibly dependent, to some extent, on the state of the tide. Table V has been condensed in Table VI to show the number of fishings in each

TABLE VI

SUMMARY OF NUMBERS OF FISHINGS AND SEALS SEEN AT GOSWICK AND CHESWICK, 1959–1963

Time	*No of times nets fished*	*No. of seals seen*	*No. seen per fishing*	*No. of seals killed*	*No. killed per fishing*
00.00–06.00	347	120	0·35	15	0·043
06.00–12.00	479	473	0·99	17	0·035
12.00–18.00	363	514	1·42	21	0·058
18.00–24.00	455	469	1·03	14	0·031

6-hours' period together with the number of seals seen and the number killed for the five years, and from these totals the number of seals seen and the number of seals killed per fishing have been calculated.

It would appear that seals are less numerous from midnight to 6 o'clock in the morning but this may be the result of poor visibility and other difficulties in observing at this time of the morning. Obviously more seals were observed from midday to 6 o'clock in the evening than at any other period. However, the final column of Table VI giving the number of seals killed per fishing (most of the animals are found drowned in the nets) would seem to indicate that there is less variation in the number of seals around the nets from the one 6-hours' period to another than the numbers observed suggest.

(iii) Throughout the returns by the netsmen there is evidence of a tendency for seals to feed mainly on the flowing tide.

(iv) Seals appear to be less numerous around fishing stations during stormy weather, but it is possible that results may be affected by observational difficulties under these conditions or by the absence of observers when, as frequently happens, fishing is temporarily abandoned. Occasionally a movement of seals has been observed towards less exposed stations.

(v) Seals appear to be troublesome when the sea water is clear, and to be less active when it is cloudy with dense plankton or fine matter in suspension.

(vi) Although seals generally concentrate on fish shoals close to the coast they frequently prey on shoals (white-fish as well as salmon) at a distance of several miles from the shore. Evidence of this has been obtained from fishermen using drift-nets and cod-nets and it has been confirmed by research experience. It has also been observed that they are able to kill salmon and other fish without the assistance of natural or artificial barriers.

(vii) Seals have been known to concentrate on a particular section of the coast for a time and then, for no apparent reason, to shift to another locality.

Although there is no obvious explanation of some of these characteristics others would seem to be associated with the movements or habits of the fish shoals.

Discussion of the results

Table IV summarises for each station in each year, the following information:

(1) the period of observations;
(2) the number of weeks in which observations were recorded;
(3) the number of seals seen in the vicinity of the nets (see p. 9);
(4) the number of seals seen killing or eating salmon near the nets;
(5) the number of salmon heads and other remains observed in the nets and on the adjoining beach;
(6) the calculated average number of seal visits to the nets per working week of $5\frac{1}{2}$ days (more accurately $5\frac{1}{4}$ days, since the weekly close time lasts 42 hours).

The records vary from station to station and also from year to year at the individual stations. The records are nevertheless interesting in that the relative degree of interference by seals, as measured by the conservatively estimated average number of seal visits per working week, is remarkably consistent over the five years at each station, although seal depredations appear to have been heavier in 1959 than in any other year. Despite the varied nature of the coastline covered by the stations, the different types of gear used, the variable weather and the different times of the observations throughout the fishing season, the records are nevertheless regarded as representative of the salmon fishery on the Scottish east coast. Consequently, the overall estimated average derived from all the stations may be regarded as representative of the number of seals *observed* at all stations on the Scottish east coast every working week. As shown in Table IV the estimated averages for the five years are as follows (the figures in brackets again being estimated on the more conservative assumption that never more than one seal was around the nets per fishing *unless* there were known to be two or more (page 12)):

1959 = 6·7	1960 = 3·0	1961 = 3·2	1962 = 3·4	1963 = 2·9
(4·0)	(2·1)	(2·2)	(2·0)	(1·6)

Estimate of the number of seal visists to fishing stations on the Scottish east coast

The above averages represent the numbers seen during the relatively short periods of observation on $5\frac{1}{2}$ days each week. At most stations the observation time is no more than and is probably less than the fishing time, averaging about four hours per day at most stations. At those stations which are overlooked by a fishermen's bothy or by the house of a member of the fishing crew the possible observation time is greater and may occasionally extend over as much as ten to twelve hours per day. However, as already indicated, the actual time spent watching for seals is probably less and may not exceed eight hours. Allowing for both types, on the basis of information given in respect of eight stations on the Kincardineshire and Angus coasts, the average observation time has been estimated to be about $5\frac{1}{2}$ hours in each 24 hours. Furthermore, although it has been shown that seals may be active at the fishing stations at any hour of the day, it is proposed for present purposes to regard their feeding time as confined to within 16 hours daily. Moreover, even if, when a seal is observed on two occasions, it has in fact been the same seal, it is perhaps not an unreasonable assumption that the animal had eaten at least twice in the course of 16 hours, so that it is likewise reasonable to regard the two counts as two feeding visits, although the estimates below are also given in brackets on the assumption that there was in fact only one seal visit.

It must also be remembered that fishing is confined to $5\frac{1}{2}$ days per week. Consequently the average number of seals seen at the stations each year must be raised to give the approximate number visiting the stations every full week during the season. Thus the average for 1959 will be:

$$6{\cdot}7 \times \frac{16}{5\frac{1}{2}} \times \frac{7}{5\frac{1}{2}} = 24{\cdot}81\ (14{\cdot}81)\ \text{seals seen}$$

and presumed visiting for feeding, and similarly for the other years:

1960 = 11·11 (7·77)
1961 = 11·85 (8·15)
1962 = 12·59 (7·41)
1963 = 10·74 (5·92)

Having estimated the average number of seal visits to each station per recorded week, it should now be possible to obtain an approximation to the number of seal visits to each station during the fishing season. This generally begins in the second half of February and ends in the last week of August, covering about 30 weeks in all. Although seals are now known to be present on all sections of the Scottish coast throughout the entire year, it is agreed that towards the end of the fishing season they are seen much less frequently in some localities than in others. In order to avoid an over-statement, it is therefore proposed to regard the fishing season as consisting of 26 weeks. The average number of seal visits to each station throughout the fishing season is, therefore, the weekly average multiplied by 26.

It now remains to estimate the number of seal visits to all netting stations on the east coast throughout each season.

To do so the yearly averages for the stations at which observations were recorded throughout the fishing season must be multiplied by some factor representing the number of stations. Unfortunately, this cannot be determined accurately since it varies throughout the season, and with the growth of mechanisation in the fishery there is a tendency for stations to be combined and worked as one unit. The number of nets or traps in use is known approximately but this is also variable throughout the season, being determined by weather, seal activity and other factors, although in general it rises to a maximum in July and then declines quickly as the season draws to a close. The average maximum number of traps fished on the Scottish east coast annually over the five years 1959–63 was about 640 although the number has been declining yearly. These traps are distributed continuously over two sections of the coast from Goswick in Northumberland to Cockburnspath in Berwickshire and from Lunan Bay, Angus, to Wick in Caithness—a distance of roughly 250 miles (excluding the inner parts of the firths in the inner Moray Firth, where the use of fixed engines is prohibited). The average number of traps per mile of coastline is, therefore, less than three. Traps are not, however, evenly distributed along the coast and may vary from one to twenty per station; moreover, some stations occupy less than one mile of coastline while others extend over several miles. In these circumstances it has been considered reasonable to regard a 'station' as occupying an average distance of about three miles of coast and fishing an average of about eight traps at the height of the season. Consequently, this gives a total of about 80 sections of coastline or 'stations'.

In order to estimate the total number of seal visits to salmon nettings stations on the Scottish east coast (together with a few miles of the Northumberland coast) the average number of seal visits per station per week in each fishing season must, therefore, be multiplied first by 26 to give the number of visits per station during the season, and then by 80 to give the grand total for all stations on the coast. This gives the following totals:

1959 = 51,605 (30805) — say 52,000 (31,000)
1960 = 23,109 (16162) — say 23,000 (16,000)
1961 = 24,648 (16952) — say 25,000 (17,000)
1962 = 26,187 (15413) — say 26,000 (15,000)
1963 = 22,339 (12314) — say 22,000 (12,000)

Table IV also gives the numbers of seals observed killing and/or eating salmonids near the nets. Facilities for observations of this nature naturally vary from one station to another, and of the 758 instances over the five years, no fewer than 392 were recorded at two fishing stations near the mouth of the North Esk river. Most of the fish seen being killed and eaten were referred to in the returns as salmon. Grilse or sea trout were rarely mentioned but it cannot be assumed that these fish are not eaten by seals. Indeed the smaller fish may be just as frequently preyed upon, but, being smaller, they are more easily eaten and do not present the same problem to the seals as do the bigger salmon, which have to be seized and carried to the surface before being consumed. On the other hand it must be mentioned that both grilse and sea trout have a shorter season than salmon.

The numbers of salmon heads and other remains found in the nets or washed up on the adjoining beach are also included in Table IV. These observations also vary from station to station, and, even more noticeably than in the previous records, they tend to be concentrated at particular places. This

is understandable since salmon remains which are washed ashore are very largely carried there by local tidal currents and occasionally by storms when the wind is in a particular direction. Of the 886 records in this category 412 were noted at the Watermouth Station at the mouth of the North Esk, from which it may be concluded either that circumstances favour seal predation on salmon in the locality or that this station is particularly well sited for such observations.

These two sets of observations help to confirm the predation of seals on salmon. They also show that in particular localities the damage done to local salmon stocks, and hence to the fishery, attains considerable proportions. A concentration of fish, for example, near the mouth of the North Esk may be an important factor. No precise assessment of the extent of the damage can be made, but it is evident that if the killing of salmon at every fishing station on the coast is in the same proportion or even in a smaller proportion to the number of seals observed, as it is at those few localities where it has been possible to count the numbers of seals actually seen killing fish and the numbers of dead fish, then the overall damage to salmon stocks would appear to be much greater than the records in Table IV suggest.

Estimate of loss to salmon fishery

It is now generally accepted that the grey seal population of the Farne Islands is about 4,500 and that of the Orkney Islands about 10,000. At the end of the breeding season the seals disperse to feed. Current investigations have also shown that the grey seal is very largely a coastal animal and that the Scottish east coast is a favoured feeding place. Seals from the Farne Islands and from the Orkneys have, however, been found on other coasts, both in the United Kingdom and on the Continent, including the Faroes and Iceland. No estimate can be made of the numbers which remain to feed on the Scottish east coast, but assuming that no more than a quarter of the combined population of the Farnes and Orkneys do so, this means that the resident grey seal population from Northumberland to Caithness amounts to rather more than 3,000 animals throughout the salmon fishing season. On this basis the number of seal-feeding-days during the fishing season of say 26 weeks, is in the region of 600,000. The conservative estimate of the yearly number of seal visits to salmon fishing stations from 1959 to 1963 assessed above, some 30,000 (18,000), therefore represents but a small proportion of the possible total, and this discrepancy alone would seem sufficient to discount any risk that the estimates are other than conservative.

If one now assumes that each seal visit to the netting stations results in the killing of one salmonid —whether salmon, grilse or sea trout—the yearly number of visits could be regarded as indicating the possible number of salmonids killed. It may reasonably be argued that seals do not succeed in killing a salmonid at every visit. At the same time the fishermen's logs from all sections of the coast contain numerous references to the killing of more than one fish by individual seals within the short period of observation. Some of the reports also refer to the killing of three or four fish by single seals within varying periods of up to an hour, and in this connection attention should be drawn to the various published statements of the observed killing of more than one salmon by a single seal. Objections may well be raised to this on the grounds that a seal does not require so much food, but it must be pointed out that seals rarely consume the entire fish.

It seems reasonable, therefore, bearing in mind the conservative methods of calculation, to assume that each estimated seal visit to the vicinity of the nets results, on an average, in the killing of one salmonid. Table VII shows the numbers of fish thus assessed as destroyed for 1959–63, represented as equivalent percentages of (1) the total salmonid catch by all fishing methods in Scottish east coast salmon fishery districts and of (2) the total salmonid catch by fixed engines (i.e. bag-nets, fly-nets, etc.) in the same districts.

The third column in Table VII represents, therefore, the possible annual loss to the salmon fishery as a whole on the east of Scotland, and the fourth column the possible loss to the coastal nets section of the fishery, i.e. that most directly affected by seal predation and the source of the returns analysed in this paper. Over the five years the estimated average annual loss of salmon, grilse and sea trout amounts to 6·0% (3·7%) of the total catch by all methods in eastern Scottish districts and 20·3% (12·6%) of the catch by fixed nets on the Scottish east coast.

TABLE VII

(*a*) CONSERVATIVELY ESTIMATED NUMBERS OF SEAL VISITS TO FIXED SALMON NETS ON THE SCOTTISH EAST COAST = POSTULATED NUMBERS OF SALMONIDS KILLED BY SEALS (STILL MORE CONSERVATIVE ESTIMATES IN BRACKETS);

(*b*) THE EQUIVALENT PERCENTAGES OF THE TOTAL CATCH OF SALMONIDS IN SCOTTISH EAST-COAST DISTRICTS;

(*c*) THE EQUIVALENT PERCENTAGES OF THE SALMONID CATCH BY FIXED ENGINES IN THE SAME DISTRICTS

Year	(*a*)	(*b*)	(*c*)
1959	51605(30805)	10·5(6·3)	34·7(20·7)
1960	23109(16162)	4·9(3·4)	16·0(11·2)
1961	24648(16952)	5·8(4·0)	18·9(13·0)
1962	26187(15413)	4·6(2·7)	17·4(10·2)
1963	22339(12314)	4·4(2·4)	14·2(7·8)
1959–1963	147888(91646)	6·0(3·7)	20·3(12·6)

From statistics of the salmon fishery (see Fisheries of Scotland Annual Reports for 1959–63) it has been estimated that the average weight of the salmon, grilse and sea trout caught in Scotland over the years 1959–63 was from 6·0 to 6·6 lb and that the average price paid to the fisherman was from 6/6 to 7/4 per lb. While it is recognised that not every salmonid so preyed upon is an immediate loss to the catches (although there is good reason to suppose most are), a simple calculation on the basis of these figures shows that the possible average annual loss to the industry on the Scottish east coast, through seal predation on fish alone over these years, was about £67,000, most of which would appear to have been borne by the coastal netsmen. Even on the assumption that never was more than one seal present and feeding when one or more seal observations were recorded, this loss would amount to about £42,000 —and it should be recalled that this estimate concerns only salmonids estimated as likely to have been killed by the seals *seen* by fishermen in the vicinity of their nets. In addition, there are salmonids killed elsewhere, salmonids diverted from the nets, salmonids damaged but subsequently caught alive, and, of course, net damage and consequent escape of salmon, etc. Against this apparently conservative estimate, it may be argued as above that the seals may not kill one salmonid on average for each of their visits, and this is possible (although they may also kill more!) But it would seem reasonable to balance against this and any other likely risks of over-estimation in these admittedly crude calculations, the likelihood that the total number of seal visits has indeed been greatly under-estimated by comparison above with the much larger numbers of possible visits (p. 17). There seems good reason to believe that a loss to the netsmen of some £50,000 per annum is by no means a high estimate.

EXAMINATION OF LOGS KEPT BY FOREMEN AT NET-AND-COBLE STATIONS IN THE MOUTH OF THE RIVER TWEED

Numbers of Seals Observed at Fishing Stations

The information given in the logs kept by the net-and-coble fishermen at two fishing stations in the mouth of the River Tweed has been summarised in Table VIII. The first of these stations, Sandstell, is located on the south bank of the river opposite the landward end of Berwick pier, and the second, Hallowstell, also on the south bank but about three-quarters of a mile upstream. In addition to recording the numbers of seals seen at the stations daily during fishing operations (about 8 hours daily for 5½ days per week) the logs also give the number of occasions on which seals interfered with fishing operations by taking, or by attempting to take, fish from the net, and the numbers of seals actually observed killing and eating salmonids in the vicinity of the netting station. Unfortunately no observations were recorded in 1959 and those of 1961 were not sufficiently detailed to permit comparison with the other years.

TABLE VIII

SUMMARIES OF LOGS KEPT BY FISHERMEN AT NET-AND-COBLE FISHING STATIONS IN THE MOUTH OF THE RIVER TWEED—SANDSTELL (S) AND HALLOWSTELL (H)

Year	Month	*No. of days fishing*		*Greatest no. of seals seen in one day*		*Total no. seals seen in month*		*No. of seals seen killing fish*		*No. of days on which seals interfered with fishing*		*Average no. of seals seen per fishing day*	
		S	H	S	H	S	H	S	H	S	H	S	H
1956	April	20	20	4	2	22	7	5	0	1	0	1·1	0·4
	May	25	25	5	2	49	2	2	0	8	0	2·0	0·1
	June	22	22	10	1	71	3	5	0	10	0	3·2	0·1
	July	24	24	5	3	58	13	6	3	10	1	2·4	0·5
	August	10	10½	7	0	24	0	2	0	5	0	2·4	0·0
	September	—	4	—	2	—	8	—	0	—	0	—	2·0
	April–September	101	105½	10	3	224	33	20	3	34	1	2·2	0·3
1957	March	16	16	8	2	58	10	8	5	4	0	3·6	0·6
	April	24	24	4	1	56	2	1	0	3	0	2·3	0·1
	May	25	25	7	0	85	0	1	0	3	0	3·4	0·0
	June	22½	22½	2	0	16	0	0	0	0	0	0·7	0·0
	July	24½	24½	6	1	48	2	2	0	2	0	2·0	0·1
	August	16	17½	4	2	23	6	2	0	8	0	1·4	0·3
	September	11	11	2	2	16	10	0	4	1	1	1·5	0·9
	March–September	139	140½	8	2	302	30	14	9	21	1	2·2	0·2
1958	March	21	22	7	5	38	43	2	5	4	2	1·8	2·0
	April	20½	21½	5	2	45	5	0	0	1	1	2·2	0·2
	May	24½	25½	9	2	93	7	1	4	8	1	3·8	0·3
	June	21½	22½	15	0	92	0	16	0	9	0	4·3	0·0
	July	23	23	7	3	73	14	31	8	9	0	3·2	0·6
	August	22	22	4	1	48	1	4	0	4	0	2·2	0·0
	September	11	11	7	0	46	0	7	0	4	0	4·2	0·0
	March–September	143½	147½	15	5	435	70	61	17	39	4	3·0	0·5
1960	March	4	10	3	1	8	7	0	0	0	0	2·0	0·7
	April	12	18	4	1	12	6	0	0	0	0	1·0	0·3
	May	25	25	2	0	14	0	0	0	0	0	0·6	0·0
	June	23	23	2	0	2	0	0	0	0	0	0·9	0·0
	July	23	23	2	1	29	2	0	0	0	0	1·3	0·1
	August	23	23	1	1	12	1	0	0	0	0	0·5	0·0
	September	11	11	1	0	8	0	0	0	0	0	0·7	0·0
	March–September	121	133	4	1	85	16	0	0	0	0	0·7	0·1

Fluctuations in the number of days fishing from month to month were mainly owing to interruption to fishing by heavy seas in the estuary or by spates in the river.

The number of seals seen on the fishing stations varied from day to day up to maxima of fifteen at Sandstell, on 12th June 1958, and five at Hallowstell on 4th March 1958. On many days none was seen but it should be recalled that observations were recorded only during fishing time. The numbers recorded do not, therefore, represent the total numbers of seals visiting the fishings daily.

The numbers of seals seen at each station also varied from month to month and from year to year. There is no evidence that seals are most numerous in any particular month; for example, in 1956 they were most numerous in June, in 1957 in March, in 1958 in June and September, and in 1960 in March. Over the period of the logs seals were clearly most numerous in 1958 and least so in 1960. It is unfortunate that counts were not made in 1961 as it would appear from the foremen's remarks that the numbers of seals at each fishing station were well above average in February and March of that year, although they became less numerous in April and fluctuated thereafter.

Seals were at all times more numerous at the Sandstell station, about 400 yards from the sea, than at Hallowstell, about a mile from the sea. It has been reported that seals are frequently seen further upstream, in the vicinity of the bridges, and sometimes as far as three miles from the sea, while on rare occasions they have been seen even further up river.

An impressive feature of these logs is the number of occasions on which seals have actually been seen killing fish in the fishings. In one year alone, 1958, these numered 61 at Sandstell and 17 at Hallowstell. Most of the fish killed were stated by the fishermen to be salmon. Sea trout and grilse were identified on relatively few occasions although, as will be noted elsewhere, it does not necessarily follow that seals do not also prey heavily on these fish. Seals are not infrequently seen killing kelts in the early part of the season, and during the week ending 25th February 1961 in particular it has been estimated, from reports by different observers, that many of these fish in their weak condition fell an easy prey to seals at the mouth of the Tweed.

The evidence of seals interfering with fishing operations is of particular interest. Hitherto, information about seal damage to nets has been mainly in respect of fixed or passive gears such as bag-nets. Most of the interference in the Tweed was experienced at Sandstell (94 occasions in the four years) but the Hallowstell Station was not entirely free. The nature of the interference consisted chiefly in attempts by seals to penetrate the sweep-net by leaping over the headrope, by passing under the footrope or by rounding the wings. In order to prevent them from doing so, the fishermen were obliged to keep a constant watch, but in spite of the precautions seals not infrequently succeeded in entering the net and in escaping before it could be hauled ashore. The logs include a number of references to seals taking salmon out of the net and to their tearing the meshes and making their escape.

Grey Seal Behaviour at the Mouth of the Tweed

In addition to the facts summarised in Table VIII the logs include several noteworthy observations on seal behaviour.

Seal activity during darkness

Numerous references are made to the passage of seals up river at dusk. This is more frequent in the early part of the season, from February to April, after which it is probably discouraged by the longer light of the summer months. On a few occasions seals were even seen killing salmon in the dusk. These observations support the belief already expressed by bag-net fishermen on the coast that the grey seal (it is recognised that the seals of the mouth of the Tweed are nearly all grey seals) feed by night as well as by day.

Variations in the distribution of seals at the river mouth

The varying numbers of seals seen at the fishing stations from month to month and from year to year suggest that the amount of predation on the salmon, grilse and sea trout stocks in the river is also variable. Reports by lobster fishermen on the presence and activities of seals in the river mouth, behind the pier and in Berwick Bay clearly show that when predation is low on the fishing stations in the river it is, nevertheless, continuing somewhere in the vicinity of the river mouth. Furthermore, it would appear that the congregations and activities of seals are determined not so much by the topographical features of the neighbourhood but by the distribution and movement of the fish shoals, which, in turn, are dependent on weather and river conditions as well as on biological factors and the physiological condition of the fish themselves. The relative scarcity of seals on the fishings throughout 1960 and from time to time in other years would seem, therefore, to be at least partly explained by the presence of the animals in the bay where the salmon and sea trout, and in the summer months grilse, were concentrated, presumably awaiting favourable conditions for proceeding up river. In 1958, on the other hand, fish apparently did not linger in the bay for the same length of time and were numerous in the river mouth throughout most of the fishing season; consequently this probably attracted seals into the estuary in greater numbers than usual.

Behaviour of seals in stormy weather

The logs also show a tendency for seals to enter the river during stormy weather. It is impossible to say whether this can be regarded as an attempt by the seals to avoid rough weather or whether it means that fish enter the river more readily in such conditions and thus attract the seals into the river mouth. During spate conditions, fishing in the river is frequently suspended so that observations of the presence of seals under these conditions are fewer. There is, however, evidence that seals do not avoid turbid spate waters, and in March 1958 one of the authors (B.B.R.), in company with other officers of the Scottish Office, observed at least six seals operating in the River Tweed at Berwick in the short space of 15 minutes. On this occasion conditions were boisterous in the estuary, where the river, in heavy spate and carrying much mud and debris, encountered seas whipped up by an easterly gale. These conditions apparently were not unfavourable to seals.

Seal activity prior to the fishing season

Observations also show that seals are active in or near the mouth of the Tweed for some time prior to the opening of the salmon fishing season. In 1960 this activity was evident as early as the last week in January, and for the opening week of the fishing in 1961 the logs report a larger concentration of seals and greater destruction of fish than at any time in the foreman's experience.

The effect of shooting on seals

From time to time throughout the period covered by the logs, rifle fire was used in an attempt to drive off the seals and to reduce their numbers. The difficulty of shooting seals in the water is, however, generally recognised, and, not surprisingly, this action has had only limited success in the mouth of the Tweed. With regular shooting, seals could be kept away from the fishings during working hours but owing to the danger to the public and to the expense involved this method cannot be used extensively. Frequently, too, the results of shooting cannot be observed and in the six years from 1956 to 1961 only 12 seals were killed at the Sandstell fishing; 55 were estimated to have been killed near the mouth of the river and 117 in the Tweed area as a whole.

Estimate of the Annual Number of Salmon Killed by Seals at the Mouth of the Tweed

In the final column of Table VIII the average number of seals seen on the two fishings per fishing day have been calculated for each month and year. As already indicated, these averages are in respect of an 8-hour day and since it is known that grey seals feed by night as well as by day, it may be assumed that the numbers visiting the fishings over each 24-hour day are greater. Moreover, it could be argued that the number visiting per 24 hours could be three times the average for eight hours. However, to avoid any danger of over-statement, it is proposed to regard the average for each 24-hour day as twice the 8-hour average. This procedure also appears to be justified by frequent observations of seals entering the river mouth on the flood tide to feed. On this basis, therefore, it should be possible to make a rough estimate of the number of visits by seals to the vicinity of the fishing stations over the period when seals frequent the river mouth, which for convenience may be regarded as from 1st February to 30th September, that is 242 days. The calculations which follow have been made with a view to obtaining results as comparable with those derived from fixed nets as the differences in the two methods of fishing permit. Because of the greater ease and longer periods of observation possible in the net-and-coble method of fishing, and on the strength of the knowledge that six seals have been observed hunting in the mouth of the Tweed at one time, there would seem to be little cause for doubting the accuracy of the fishermen's returns of seals seen. Consequently there would appear to be less need for a further and even more conservative calculation based on the assumption that only one seal was present during each fishing, when two or more were recorded, as has been done with the fixed-net data (p. 9).

Over the four years (see Table VIII), therefore, the minimum and conservative number of visits by seals to the fishing stations may be calculated as follows:

1956		
Sandstell	2·2 × 2 × 242 = 1065	1210 — say 1200
Hallowstell	0·3 × 2 × 242 = 145	
1957		
Sandstell	2·2 × 2 × 242 = 1065	1162 — say 1150
Hallowstell	0·2 × 2 × 242 = 97	
1958		
Sandstell	3·0 × 2 × 242 = 1452	1694 — say 1700
Hallowstell	0·5 × 2 × 242 = 242	
1960		
Sandstell	0·7 × 2 × 242 = 339	387 — say 400
Hallowstell	0·1 × 2 × 242 = 48	

No detailed information is available about the number of seals visiting the mouth of the River Tweed from October to January inclusive. As this period covers the breeding season of the Farne Island seals, when the intensiveness of feeding declines and may cease altogether for a time, it is recognised that predation on salmonids throughout the winter is considerably less than during the remainder of the year. At the same time the presence of immature and non-breeding seals on the coast and in the river mouth suggest that predation is continuing although on a greatly reduced scale.

It is evident from the annual number of visits by seals to the sweep-net fishings in the mouth of the Tweed, that considerable damage is caused to fish stocks throughout the fishing season. Visual evidence of part of this predation is provided by the reports of seals observed killing and eating salmon (Table VIII), and by the large numbers of clawed fish which are found in the catches (Rae, 1960, p. 22). It seems reasonable to suppose that the seals must find their prey in sufficient quantity, otherwise they would seek their food elsewhere. Moreover, in the absence of any contradictory evidence it seems probable that throughout the greater part of the year the most prominent fish in the estuary of the Tweed are salmon and sea trout. Consequently, there are grounds for assuming that each visit by a seal to the river in the space of eight hours results in the killing of at least one of these salmonids either in the river or in the vicinity of the river mouth. This seems to be further justified by observations in the logs that individual seals are sometimes seen killing two or more fish on a single visit to the river mouth.

It follows, therefore, that the number of salmon, grilse and sea trout killed near the two fishing stations in the mouth of the Tweed ranged over the four years under review from about 400 in 1960 to about 1700 in 1958. As already pointed out, the seals seen on the two fishings represent but a part of the seal population in the vicinity of the mouth of the Tweed. Consequently, the estimate of 1700 seals seen, and conceivably of salmon, grilse and sea trout killed, on the two fishings in 1958 provides an estimate, and probably a minimum estimate, for the whole region of the mouth of the Tweed, and since there is no evidence that the number of seals *in this area* varies from year to year in the same proportion as they do *on the two sweep-net stations*, the total, 1700, can be regarded as representing an approximation to the number of fish killed at the mouth of the Tweed every year. The average number of salmon, grilse and sea trout taken annually by net-and-coble in the River Tweed during the four years, 1956–58 and 1960, was 77,780 fish, so that the estimation of 1700 eaten by seals would represent just over 2% of the total. It is interesting to note that Lockie (1962) estimated the loss to *coastal* salmon fisheries in the Tweed fishery district from the activities of young grey seals to be about 3% of the total catch and that an undefined additional loss could be attributed to predations by older animals. If, however, as seems

probable from actual observation of the killings, the seals prey mainly on salmon, the loss to the net-and-coble fishery in the Tweed would amount to nearly 7% of the average yearly catch of salmon (24,800) by this method of fishing, and of course to an even higher proportion of the total value. On the other hand it seems likely that Sandstell and Hallowstell, because of their proximity to the sea and to the seal concentrations, must inevitably bear a heavier share of the loss than any of the other 30 or more net-and-coble stations in the river. This conclusion is based on (i) the immediate reduction in the number of catchable salmon in the river mouth; (ii) the actual observation of the removal of salmon by seals from the nets, and (iii) the probable diversion of fish from the nets by seals. It is also worthy of note that the net-and-coble fishings account for 85% of the salmon, grilse and sea trout and 70% of the salmon catch by all methods of fishing in the Tweed fishery district.

Finally, in view of the relatively small area covered by the fishings within the river mouth, on which the foregoing calculations are based, the actual number of daily visits by seals to the area of the mouth of the Tweed as a whole, and hence also the probable number of salmon, grilse and sea trout killed, may well be much greater than the minimal calculated figure.

PROPORTIONS OF SEAL-DAMAGED SALMON

In Commercial Catches

Attention has been drawn to the varying proportions of seal-damaged fish in the Scottish salmon catches (Rae, 1960, p. 21). On the evidence of salmon examined on Aberdeen fish market in 1958 and 1959 it was then estimated that 5% of the salmon caught at the mouth of the River Dee were damaged in one way or another by seals, while still remaining marketable. From information given by netsmen, it was concluded that on the Scottish coast as a whole, from 5 to 15% of the salmon catch was similarly affected, although up to 50% of individual catches on particular days was sometimes damaged. Further information on this subject gathered in recent years has confirmed these percentages.

During the period 1961 to 1964, from 70 to 90% of the salmon caught in or near the mouth of the River Dee at Aberdeen were examined, with the permission of the General Manager of the Aberdeen Harbour Board, on the fish market by members of the staff of the Marine Laboratory. All seal-damaged fish were noted day by day and the percentages of damaged fish in catches were worked out for each month. Independently of the investigations at Aberdeen, Messrs. Joseph Johnston & Sons of Montrose maintained a similar watch on fish caught on the Kincardineshire and Angus coasts. The percentages of seal-damaged fish from both sets of observations are given in Table IX in which comparable percentages for the year 1959, where available, are also included.

TABLE IX

PERCENTAGES OF SEAL-DAMAGED SALMON IN SCOTTISH EAST COAST CATCHES

A. ON ANGUS AND KINCARDINESHIRE COASTS

B. AT AND WITHIN MOUTH OF RIVER DEE, ABERDEEN

	1959		*1961*		*1962*		*1963*		*1964*	
	A	B	A	B	A	B	A	B	A	B
February	5·2	?	3·6	4·7	6·7	6·6	3·8	3·3	5·3	3·0
March	4·0	?	3·5	4·1	5·9	6·8	5·5	3·1	8·4	3·2
April	7·1	?	4·7	5·6	7·9	6·6	7·2	3·9	5·5	1·2
May	6·8	?	5·6	6·4	7·7	6·7	6·0	5·2	4·9	3·0
June	—	?	7·2	4·9	7·9	4·4	7·4	2·3	6·0	3·0
July	—	?	6·8	7·2	—	4·1	8·9	5·0	6·2	2·9
August	—	?	11·9	7·0	—	5·5	9·0	2·4	8·1	1·6
All months	6·0	5·0	5·9	5·3	7·4	6·0	6·7	3·4	6·3	2·7

During the final four months of the 1962 netting season and the whole of the 1963 and 1964 season's one of the authors (W.M.S.) kept separate records of seal-damaged salmon and grilse at four netting stations on the Angus and Kincardine coasts and at the netting station in the river North Esk. The results obtained were in reasonably close agreement with those obtained by Messrs. Joseph Johnston & Sons Ltd. (Table IX) from all their stations.

Except for minor variations from month to month and year to year the results are remarkably similar. The Angus and Kincardine data, and in one year (1961) those from Aberdeen, reveal a slight increase in the proportion of damaged fish as the season advances. On the other hand the observations at Aberdeen from 1962 to 1964 tend to show a decline in the numbers of seal-damaged fish in the latter half of the season. There are two possible reasons for this decline. In the first place it may be the result of the gradual disappearance of some or all of the seals in the locality, as occurs on various parts of the coast with the approach of the seal breeding season. On the other hand, it may arise from the appearance of grilse on the coast—an event which may divert the seals' attention, at least temporarily, from the salmon (see below).

The overall percentage of damaged fish in each year is slightly greater on the Angus and Kincardineshire coasts, where fishing is by means of fixed bag-nets and more seals are active (particularly in Angus) round the nets, than at the mouth of the Dee, Aberdeen, where a greater proportion of the catch is by net-and-coble. In view of the relative scarcity of seals in the vicinity of Aberdeen, however, one might have expected a much smaller proportion of clawed fish than on the coasts of Kincardineshire and Angus. The results given in Table IX are, therefore, regarded as further evidence in support of the view that salmon, before they reach the River Dee, run the gauntlet of seal concentrations elsewhere on the coast. Tagging experiments on salmon and grilse have indeed shown that many of these fish, after striking the coast in the Montrose area, move northwards in search of the river of their choice (Shearer, 1958, p. 8).

Of the 1019 seal-damaged salmon recorded at Aberdeen from 1961 to 1964, 96% were clawed and 4% bitten or tooth-marked. Rather less than two-thirds of the damaged fish had been recently clawed or bitten, although the proportion varied from 83% in 1961 to 35% in 1964, while the wounds in the remainder had healed or were in the process of healing.

From 1961 to 1964 many grilse were also examined for seal-damage on the Aberdeen market. The results of this examination are given in Table X.

TABLE X

PERCENTAGES OF SEAL-CLAWED GRILSE IN CATCHES AT THE MOUTH OF THE RIVER DEE AT ABERDEEN

	1961	*1962*	*1963*	*1964*
May	0·0	0·0	0·0	0·0
June	0·2	0·1	0·0	0·0
July	0·0	0·2	0·5	0·0
August	1·9	0·9	0·4	0·3
May–August	0·3	0·2	0·4	0·1

Note.—The reason for the increase in the numbers of seal-damaged grilse late in the season could be that the grilse are then larger and more likely to be able to escape than the smaller fish in the earlier part of the grilse season.

This shows that among the fish examined at Aberdeen many fewer grilse were found to be clawed by seals than were salmon. The numbers of sea trout similarly affected were even fewer than the grilse. From these records it might be assumed that seals prey on grilse and sea-trout less frequently than on salmon, but it is not at all certain that this conclusion is justified. Indeed, it might be more reasonable

to suppose that the high proportion of seal-damaged salmon is evidence of the difficulty the seal has in seizing and holding a bigger fish, and that the smaller grilse and sea-trout are more easily killed and eaten, thus leaving fewer wounded fish to survive. As already suggested, predation on grilse could explain the rather smaller number of seal-damaged salmon at Aberdeen towards the end of the fishing season.

From 1961 to 1964, an average of 255 seal-damaged salmon were noted on Aberdeen fish market annually. This does not of course represent the total number damaged in this way at Aberdeen since it has not been possible to examine all the fish caught in or near the mouth of the Dee every day, and it is probable that the yearly number is from 300 to 350. The value of seal-clawed fish on the market varies according to the extent of the injuries to the individual fish. The loss per pound may range from a few pence in lightly affected fish to several shillings in the more seriously damaged specimens. A loss of from 6d to 1/- per pound for seal-damaged fish may be regarded as a reasonable average so that the total loss in a season on 300 to 350 damaged salmon (averaging 9·7 lb each) may amount to anything from £80 to £160, depending also on the supplies and the prevailing prices. This compares with an estimated annual loss of £400 by each of two firms operating in the mouth of the River Tweed where the total catch by net-and-coble and the numbers and proportions of clawed fish are considerably greater than at the mouth of the River Dee.

During the Close Season

From 5th October 1963 to 15th February 1964, similar observations were made on salmon and grilse caught in an experimental trap in the River North Esk during the annual close season for nets.

TABLE XI

PERCENTAGES OF SEAL-DAMAGED FISH AMONG SALMON AND GRILSE CAUGHT IN THE RIVER NORTH ESK FROM 5TH OCTOBER 1963 TO 15TH FEBRUARY 1964

Year	*Month*	*No. of fish examined*	*No. damaged by seals*	%
1963	October	65	5	7·7
	November	45	3	6·7
	December	18	4	22·2
1964	January	63	8	12·7
	February	115	10	8·7
	Totals	306	30	9·8

The results, given in Table XI, are interesting in showing a higher proportion of seal-damaged fish among salmon and grilse ascending the river during the close season, when there were no nets fishing, than among fish caught by nets during the fishing season. The reason for this is not clear but it may be that, during the close season, salmon and grilse, including seal-clawed fish, are able to escape from their pursuers more readily than during the fishing season, when the nets bar possible routes of escape and indeed assist the seals in their predation. Whatever the explanation may be it is evident that seals can damage salmon and grilse without the aid of nets. Although the numbers of observations during the close season are small the monthly variations in the proportion of damaged fish are perhaps significant.

SEAL INTERFERENCE WITH DRIFT-NETTING FOR SALMON

During 1960, 1961 and 1962 a drift-net fishery for salmon developed off the Scottish east coast, chiefly within ten miles of the shore. At the end of the 1962 season, however, this method was prohibited in Scottish waters except for research purposes. At the height of this fishery in 1962 many complaints

were made by salmon drift-net fishermen (formerly whitefish fishermen) about the damage being caused by seals to both fish and gear. The Inspector of Sea Fisheries for the south-eastern Scottish area reported that 50% of the fish in some catches were seal-damaged—many of them so badly mutilated as to be unmarketable. Grey seals frequently became entangled in the drift-nets in which they were either drowned or killed by the fishermen, and in the two years 1961 and 1962 no fewer than 21 grey seals, tagged on the Farne Islands, were recovered in this way.

Confirmatory evidence of seal interference with this method of fishing and with damage to the salmon catch was obtained during experimental work carried out by Mr K. H. Balmain of the Freshwater Fisheries Laboratory, Pitlochry. From 28th January to 23rd February 1963 a programme of experimental drift-netting for salmon was carried out off the mouth of the River Tweed within an area of radius 10 miles. The purpose of this work was to tag salmon caught offshore in order to learn something about their subsequent movements. In the course of 17 trips to sea mutilation of salmon was recorded on thirteen occasions and seals were usually seen at or near the nets when this occurred. Seal-damage was heaviest during the first week and tended to fall off, as the following figures show.

Week ending	*No. of salmon caught*	*No. of salmon damaged by seals*	
2nd February	43	22	= 51%
9th February	39	15	= 38%
16th February	86	15	= 17%
23rd February	118	18	= 15%
Total	286	70	= 24·5%

This decline may have been due to changes in the distribution of the fish and of the seals, but there is evidence that a change in the fishing practice also contributed. For example, in view of the high proportion of damaged fish during the first week, it was decided to maintain a patrol along the line of the nets when these were in water, and to remove fish from the nets whenever there was evidence of their capture. This undoubtedly reduced the numbers of mutilated fish.

Of the 286 salmon caught, 70 were damaged in some way by seals. Of the 201 fish suitable for tagging, eight bore evidence of earlier seal damage in the form of healed or partially healed claw-marks. Up to the end of March 1963 30 of the tagged salmon had been recaptured, and of these five were found to have fresh claw-marks obviously sustained subsequently to the tagging. Since the 30 recovered fish were not all made available for examination at the laboratory, it is possible that more than five were damaged by seals.

A similar programme of drift-netting for salmon was carried out off the Angus coast from 4th to 30th March, when 152 salmon were caught. Only four of these fish revealed seal claw-marks (healed or otherwise) and unlike the experiments off Berwick, no seal interference was sustained during fishing operations.

This work was repeated from mid-June to mid-August of the same year. Out of 125 salmon and grilse caught off the Angus coast, 6 had sustained claw-marks—a slight increase in the proportion of fish affected compared with the spring figures. Off the mouth of the River Tweed, however, only 3 out of 115 salmon and grilse were damaged by seals, thus indicating a marked reduction in seal predation during the summer months. Although no mutilated fish were encountered during the summer programme, one of the tagged salmon was subsequently recovered from the River Tweed in a severely damaged condition.

SUMMARY

From information supplied by salmon fishermen at a number of fixed-engine stations on the Scottish coast from 1959 to 1963, the damage caused by seals to salmon nets has been studied. The amount of net-damage varies from one station to another and invariably is greater at stations where the whole fleet of nets, or the major part of it, consists of bag-nets. Seal damage is also seasonal in certain areas but persists throughout the fishing season in others. Although at nearly half the stations the amount of seal damage to the nets does not exceed 5%, at some stations it may exceed 30% by a considerable amount.

On the basis of the numbers of seals seen by the fishermen in the vicinity of the nets when they are being fished, an estimate has been made of the numbers of salmonids destroyed by seals on the Scottish east coast each year from 1959 to 1963. This loss is represented as a percentage (1) of the total salmonid catch by all fishing methods in all east coast districts, and (2) of the total catch by fixed-engines in these districts. The average annual monetary loss to the industry on the Scottish east coast is estimated at about £67,000 (£42,000 if it is assumed that only one seal was near the nets on those occasions when more than one was observed and recorded by the fishermen).

Similarly, the loss sustained by net-and-coble fishermen in the mouth of the River Tweed from seal predation has also been estimated on the basis of seals seen around the nets during fishing operations from 1956 to 1958 and in 1960. This amounts to more than 2% of the total salmonid catch by net-and-coble in the River Tweed, but may be as high as 7% of the salmon catch if, as is not unlikely, the seal prey mainly on the bigger fish.

The incidence of seal-damaged salmon and grilse which are still marketable was studied from observations on catches on Aberdeen Fish Market and from information provided by a firm operating on the Angus and Kincardineshire coasts. The possible financial loss from this source at Aberdeen has been calculated for comparison with estimates of similar losses elsewhere.

Fish caught in an experimental trap as they ascended the river North Esk during the close season for net fishing included a higher proportion of seal-clawed fish than is found in the catches by coastal fixed nets during the fishing season thus indicating the ability of seals to prey on salmon stocks without the assistance of nets.

Evidence of seal-damage to fish during experimental fishing for salmon by drift-net is also considered.

It must be emphasised that these losses represent only certain aspects of the measurable damage sustained by the salmon fisheries and that the total loss from all seal activities must be greater.

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APPENDIX I

LOG FORM

SALMON/SEAL ENQUIRY

Name of Station..... Type(s) of Nets Fished.....

Fished by.....

Date	Time of Fishing	No. of Nets		No. of Salmon Wounded	Seals		Weather	Notes[a]
		Damaged by Seals	Un-damaged		Seen	Killed		

[a]Any useful observations, e.g. any salmon heads picked up on beach, any seals seen with kill, should be entered here.

Have any measures been taken against seals during the week?.....

If measures have been taken, what were the results?.....

Please send this form to the FRESHWATER FISHERIES LABORATORY, FASKALLY, PITLOCHRY, PERTHSHIRE, each week.

APPENDIX II

WEEKLY RETURNS OF NETS DAMAGED BY SEALS

THE AMOUNT OF SEAL DAMAGE TO NETS EXPRESSED AS A PERCENTAGE OF THE TOTAL NUMBER OF NETS FISHED DURING THE WEEKS ENDING ON THE DATES INDICATED

APPENDIX TABLE 1

1959

Name of Station	11/4	18/4	25/4	2/5	9/5	16/5	23/5	30/5	6/6	13/6	20/6
Cheswick	—	—	6·3	15·5	14·3	7·8	7·7	0	0	8·2	9·7
Goswick	—	—	3·0	9·3	8·4	9·1	8·3	5·1	4·0	4·4	7·7
Boddin	4·1	11·1	22·0	19·4	16·7	22·0	10·1	11·1	7·9	1·1	0
Watermouth	20·5	5·0	0	0	14·3	12·5	16·7	4·5	10·4	1·9	10·0
Rockhall	0	7·1	0	2·6	0	10·0	0	0	0	0	5·6
Cruden Bay	—	29·2	34·7	26·5	32·8	35·7	51·6	38·2	36·3	49·4	25·5
Ugie, Buchanhaven	—	—	—	—	0	35·0	91·7	50·0	36·0	40·0	10·0
Pennan	—	18·2	29·1	23·6	13·3	13·3	34·1	28·8	18·2	0	5·7
Gardenstown	—	0	1·1	0	1·0	0	2·2	10·0	7·6	0	0
Portgordon	—	44·4	52·8	66·7	81·1	42·7	29·7	36·5	27·8	31·5	38·9
Gallowhill	2·8	0	4·8	4·2	2·1	2·1	8·3	2·1	—	—	—
Cromarty	8·3	0	2·8	—	—	0	8·3	8·3	—	—	—
Berriedale	—	61·1	52·4	43·8	12·5	25·0	15·6	—	—	—	—
Brochel Castle	—	—	—	—	0	4·3	4·2	16·7	6·9	16·7	11·1

— indicates no record.

APPENDIX TABLE 1 1959——*Continued*

Name of Station	27/6	4/7	11/7	18/7	25/7	1/8	8/8	15/8	22/8	29/8	5/9
Cheswick	4·9	0	2·1	1·0	0	1·3	3·5	1·1	0	—	—
Goswick	8·0	4·8	2·0	2·1	4·0	0	0	0	2·0	—	—
Boddin	1·1	0	0	1·1	0	0	0	0	0	—	—
Watermouth	6·6	4·5	0	1·8	0	0	0	0	0	0	—
Rockhall	0	0	0	—	0	0	0	0	0	—	—
Cruden Bay	43·5	28·4	31·4	25·0	17·7	30·6	35·3	22·8	59·8	48·8	36·0
Ugie, Buchanhaven	36·7	66·7	63·3	45·0	32·0	55·0	33·3	36·0	20·0	16·0	20·0
Pennan	0	—	—	—	—	—	—	—	—	—	—
Gardenstown	0	—	—	—	—	—	—	—	—	—	—
Portgorden	35·2	41·7	31·5	35·6	27·8	14·8	31·5	20·8	—	—	—
Gallowhill	—	—	—	—	—	—	—	—	—	—	—
Cromarty	—	—	—	—	8·3	—	—	—	—	—	—
Berriedale	—	—	—	—	—	—		—	—	—	—
Brochel Castle	6·7	9·5	22·9	11·9	7·1	—	—	—	—	—	—

— indicates no record.

APPENDIX TABLE 2

1960

Name of Station	20/2	27/2	5/3	12/3	19/3	26/3	2/4	9/4	16/4	23/4	30/4	7/5	14/5	21/5	28/5
Cheswick . .	—	0	8·8	7·1	2·2	0	0	0	5·0	1·3	16·1	9·4	—	5·7	5·9
Goswick . .	—	7·0	7·0	0	2·2	3·4	3·3	0	3·3	5·6	9·1	0	0	0	2·3
Boddin . . .	12·5	4·3	10·0	—	66·6	0	72·7	—	0	5·6	8·7	24·3	0	5·6	2·0
Watermouth .	—	0	0	—	—	—	—	—	0	0	15·5	9·0	50·0	6·8	12·8
Charleton . .	—	0	—	—	—	—	—	—	—	—	4·6	3·0	8·3	10·6	3·9
Woodston, Fly .	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0
Woodston, Bag .	0	6·3	0	—	0	—	28·6	75·0	0	5·4	5·2	1·5	0	0	0
Rockhall . .	28·6	24·0	0	—	0	37·5	36·4	50·0	0	0	0	2·6	7·1	8·6	33·0
Johnshaven . .	8·3	8·0	75·0	—	—	—	18·8	25·0	15·6	1·9	1·4	0	0	0	0
Cruden Bay .	—	—	6·3	—	—	—	0	—	0	29·0	20·0	28·1	33·3	32·0	29·6
Ugie, Buchanhaven	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pennan . .	—	33·3	31·3	72·7	25·0	50·0	50·0	75·0	0	0	8·6	0	8·3	0	—
Gardenstown .	0	2·1	24·0	25·0	18·0	42·2	0	14·8	0	0	5·2	7·0	0	0	0
Portgordon . .	—	—	100·0	100·0	75·0	56·1	65·0	44·0	20·0	60·0	60·0	—	—	—	—
Nairn . . .	—	—	—	23·3	8·3	0	5·6	0	0	0	0	0	4·2	21·0	9·3
East Delnies . .	—	0	13·1	0	50·0	9·1	24·0	40·0	30·0	37·5	33·3	11·9	8·3	8·3	2·1
West Delnies . .	—	20·0	33·3	33·3	0	35·0	85·0	0	8·0	12·0	13·3	17·1	2·5	7·5	2·5
Gallowhill . .	—	—	—	—	—	—	—	—	—	—	0	16·7	10·0	8·3	5·6
Cromarty . .	—	—	—	—	—	—	—	—	—	—	5·6	11·1	16·7	16·7	5·6
Melvich . .	—	—	—	—	—	—	—	—	—	—	—	—	—	33·3	20·0
Brochel Castle .	—	—	—	—	—	—	—	—	—	—	—	18·2	11·8	12·5	12·5

indicates missed visit because of weather conditions

APPENDIX TABLE 2 1960——*Continued*——

Name of Station	4/6	11/6	18/6	25/6	2/7	9/7	16/7	23/7	30/7	6/8	13/8	20/8	27/8	3·9	10/9
Cheswick . .	6·9	2·8	1·1	6·9	—	0	1·2	2·0	—	0	—	—	2·0	—	—
Goswick . .	1·4	0	3·3	0	0	0	5·8	1·5	—	—	—	—	—	—	—
Boddin	3·7	4·4	2·0	1·0	1·0	0·6	0·8	0	0	0	—	5·6	—	0	—
Watermouth .	3·8	11·1	1·1	3·4	18·4	5·3	1·0	8·2	2·2	1·3	0	0	0	0	—
Charleton . .	2·5	0	—	2·3	13·6	0	0	0	0	0	0	0	0	0	—
Woodston, Fly .	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
Woodston, Bag .	0	2·8	0	1·1	0	0	0	0	0	0	0	0	—	0	—
Rockhall . .	0	1·1	1·0	0	4·1	0	0	1·8	0	0	0	0	0	0	—
Johnshaven . .	0	0	3·2	0	0	0	0	0	0	3·9	0	0	4·2	—	—
Cruden Bay .	16·8	15·0	15·0	8·8	4·2	25·0	26·3	28·8	15·6	17·2	12·0	10·0	17·9	10·1	0
Ugie, Buchanhaven	—	0	0	0	—	14·3	18·2	48·0	3·3	16·7	0	0	3·3	20·0	0
Pennan . .	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Gardenstown .	0	0	0	0	0	0	—	—	—	—	—	—	—	—	—
Portgordon . .	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nairn . . .	1·9	0	0	0	0	0	0	0	0	0	0	—	—	—	—
East Delnies . .	12·5	6·3	8·3	8·3	10·7	0	2·4	2·1	2·8	0	0	—	—	—	—
West Delnies . .	17·5	2·5	2·5	15·0	16·7	0	5·9	5·0	2·9	2·9	0	—	—	—	—
Gallowhill . .	2·8	0	0	5·6	19·4	5·6	2·8	2·8	0	0	8·3	—	—	—	—
Cromarty . .	0	2·8	0	2·8	11·1	2·8	5·6	2·8	0	0	8·3	—	—	—	—
Melvich . .	13·3	30·0	13·3	10·0	10·0	6·7	13·3	16·7	6·7	0	—	—	—	—	—
Brochel Castle .	25·0	16·7	26·7	23·3	20·5	19·0	7·1	2·4	11·9	11·9	8·6	0	—	—	—

— indicates no record, mainly because of weather conditions

APPENDIX TABLE 3

1961

Name of Station	11/2	18/2	25/2	4/3	11/3	18/3	25/3	1/4	8/4	15/4	22/4	29/4	6/5	13/5	20/5	27/5
Cheswick	—	—	2·9	1·6	1·3	3·8	—	—	1·4	3·8	1·3	0	2·5	2·5	6·3	5·4
Goswick	—	0	4·3	8·3	6·7	4·1	0	—	8·3	4·4	5·4	6·7	2·5	1·6	4·1	6·4
Boddin	—	0	17·5	0	9·1	22·2	18·2	27·5	14·7	13·0	21·0	14·9	18·9	18·2	11·8	10·0
Rossie	—	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Watermouth	—	33·3	25·0	10·0	11·4	20·5	7·7	0	0	0	12·5	—	0	4·5	6·1	6·7
Charleton	—	10·0	25·0	11·8	29·5	13·6	3·2	0	0	0	0	—	22·5	3·0	7·6	3·7
Woodston, Fly	—	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Woodston, Bag	—	5·0	33·3	3·6	0	2·3	0	0	0	0	0	0	0	1·5	0	0
Rockhall	—	0	26·0	6·3	14·5	16·4	8·6	2·6	0	4·5	3·2	12·0	4·3	4·3	2·6	4·3
Johnshaven	—	12·0	0	0	13·3	8·9	14·0	12·7	5·4	14·3	17·1	8·6	9·5	4·1	7·1	4·1
Cruden Bay	—	—	—	100·0	18·4	26·1	11·3	15·6	47·1	42·5	30·0	31·5	29·5	4·7	9·2	14·7
Ugie, Buchanhaven	—	—	—	—	—	—	—	—	—	—	—	—	6·7	0	5·0	6·7
Pennan	0	20·0	12·5	15·0	15·0	45·8	16·7	0	0	0	12·0	20·0	4·0	0	—	—
Gardenstown	0	2·0	4·0	17·8	16·0	6·7	0	3·3	0	4·2	—	—	—	—	—	—
Nairn	—	—	—	—	0	10·0	0	0	16·0	0	0	0	2·9	0	14·3	22·2
East Delnies	—	—	—	—	—	66·7	30·0	30·0	4·0	23·3	18·2	8·6	12·5	5·0	5·0	2·5
West Delnies	—	—	—	—	80·0	40·9	20·8	20·8	28·6	13·9	5·6	13·9	13·9	2·8	7·1	3·6
Gallowhill	—	—	—	—	—	—	—	—	—	—	—	—	—	4·2	0	0
Cromarty	—	—	—	—	—	—	—	—	—	—	—	6·3	3·4	8·3	5·6	8·3
Berriedale	—	—	—	—	—	62·5	62·5	5·0	—	—	—	—	—	—	—	—
Brochel Castle	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	16·7

— indicates no record

APPENDIX TABLE 3 1961—*Continued*

Name of Station	3/6	10/6	17/6	24/6	1/7	8/7	15/7	22/7	29/7	5/8	12/8	19/8	26/8	2/9	9/9
Cheswick . . .	0	3·9	0	0	2·5	0	3·8	2·0	—	—	—	—	—	—	—
Goswick . . .	8·3	3·3	0	1·8	3·5	0	4·1	11·8	—	—	—	—	—	—	—
Boddin . . .	6·6	3·0	2·0	0	0	0	0	0	1·4	2·1	1·9	0	0	0	—
Rossie . . .	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
Watermouth . .	8·1	6·8	8·8	1·0	8·9	0	0	0	0	0	0	0	0	0	—
Charleton . . .	0	1·1	1·6	0	0	0	0	0	0	0	0	0	0	0	—
Woodston, Fly . .	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
Woodston, Bag . .	0	2·3	0	6·9	0	0	0	0	0	0	0	0	0	0	—
Rockhall . . .	5·0	3·0	0	0	0·8	0·8	0	0	0	0	0	0	0	0	—
Johnshaven . .	0	3·7	0	0	0	0	0	0	0	0	0	0	0	0	—
Cruden Bay . .	8·0	9·3	1·3	0	23·8	14·8	0	6·3	0	1·3	9·4	1·3	17·5	12·5	0
Ugie, Buchanhaven .	0	0	0	3·3	6·7	27·8	16·7	33·3	0	0	13·3	26·7	16·7	3·3	5·0
Pennan . . .	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Gardenstown . .	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nairn . . .	2·9	0	0	0	0	0	0	0	0	0	0	3·1	0	—	—
East Delnies . .	10·0	10·0	9·4	4·2	4·4	2·2	0	0	0	0	2·9	17·9	9·1	—	—
West Delnies . .	5·7	14·3	2·1	0	0	12·5	0	0	2·5	6·7	3·3	17·6	12·5	—	—
Gallowhill . . .	5·6	2·8	2·8	5·6	5·6	5·6	0	5·6	0	5·6	2·9	0	—	—	—
Cromarty . . .	11·1	8·3	2·8	8·3	8·3	5·6	2·8	11·1	8·3	5·6	5·6	8·3	—	—	—
Berriedale . . .	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Brochel Castle . .	11·1	32·0	20·8	11·9	11·9	7·1	4·8	9·5	3·8	—	—	—	—	—	—

— indicates no record

APPENDIX TABLE 4

1962

Name of Station	17/2	24/2	3/3	10/3	17/3	24/3	31/3	7/4	14/4	21/4	28/4	5/5	12/5	19/5	26/5	2/6
Cheswick & Goswick	0	4·0	0	0	0	0·9	1·6	1·8	0·9	3·2	0	0	0	1·2	0	1·4
Boddin . .	—	13·2	25·0	10·0	10·7	3·7	15·6	18·8	3·2	18·7	9·1	16·7	4·5	7·1	0	1·0
Rossie . .	0	0	0	0	0	—	0	0	0	0	0	0	0	0	0	0
Watermouth .	—	0	—	—	—	0	0	—	0	—	22·7	16·0	7·6	16·3	19·4	21·3
Charleton . .	—	0	—	0	—	5·0	0	0	3·8	—	10·9	5·0	5·0	10·0	8·8	3·2
Woodston, Fly .	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Woodston, Bag .	—	3·4	—	0	0	0	11·1	0	4·2	—	0	0	0	0	1·0	0
Rockhall . .	—	6·0	—	0	0	3·3	10·0	22·7	5·8	—	6·8	2·6	5·8	1·3	0	2·2
Johnshaven .	—	3·0	0	4·3	0	0	0	9·4	7·1	0	9·5	0	2·4	14·2	0	0
Cruden Bay .	—	—	3·1	—	11·1	2·0	36·7	—	2·0	2·5	8·0	29·1	33·6	10·4	0	14·3
Ugie, Buchanhaven	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Gardenstown .	—	0	14·3	24·0	8·6	9·1	0	0	0	0	0	0	0	3·6	0	0
Portgordon . .	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nairn . .	—	—	—	0	0	0	15·0	5·0	50·0	6·7	0	2·2	2·8	0	0	0
East Delnies .	—	—	—	0	10·0	10·0	5·0	0	10·0	3·3	8·6	33·3	26·7	13·0	19·3	29·6
West Delnies .	—	—	—	16·7	14·3	11·1	26·8	0	0	46·4	25·0	13·9	5·7	28·6	8·3	15·6
Cromarty . .	—	—	—	—	—	—	—	—	—	—	—	4·9	8·2	3·1	1·8	8·3
Berriedale . .	—	—	—	16·7	16·7	8·3	12·5	80·0	61·1	44·4	50·0	40·9	33·3	29·7	20·0	—
Brochel Castle .	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

— indicates no record

APPENDIX TABLE 4, 1962—*continued*

Name of Station	9/6	16/6	23/6	30/6	7/7	14/7	21/7	28/7	4/8	11/8	18/8	25/8	1/9	8/9	15/9
Cheswick & Goswick	0	1·3	1·3	0	0	0	0	0	0	0·9	0	0	0	0	0
Boddin	0·8	0	0	1·0	2·5	2·9	3·2	0	1·0	2·1	0	0	0	—	—
Rossie	0	0	0	0	0	0	0	0	0	0	0	0	0	—	—
Watermouth	8·9	2·3	0	1·0	2·0	1·1	0	0	0	0	0	0	0	—	—
Charleton	2·3	1·0	0	0	0	0	1·9	1·8	0	0	0	0	0	—	—
Woodston, Fly	0	0	0	0	0	0	0	0	0	0	0	0	0	—	—
Woodston, Bag	0	0	0	0	0	0	0	0	0	0	0	0	0	—	—
Rockhall	1·0	0	0	0·9	0	0	0	0	0	0	0	0	0	—	—
Johnshaven	0	1·4	0	0	0	0	0	0	0	0	0	0	0	—	—
Cruden Bay	11·4	7·1	11·9	21·9	7·8	12·1	37·5	19·0	21·4	15·6	8·0	0	0	—	—
Ugie, Buchanhaven	0	6·7	0	18·8	18·5	35·0	18·8	46·7	26·7	26·7	15·4	30·0	37·5	33·3	—
Gardenstown	0	0	0	1·0	0	0	—	—	—	—	—	—	—	—	—
Portgordon	—	—	54·3	37·1	35·7	33·3	28·6	7·1	28·6	—	34·3	—	—	—	—
Nairn	0	0	0	0	0	0	0	0	0	0	0	0	—	—	—
East Delnies	11·1	7·4	7·4	5·6	18·5	11·1	9·3	5·6	5·6	5·6	42·5	11·1	—	—	—
West Delnies	25·5	1·9	0	0	0	0	0	0	—	0	—	0	—	—	—
Cromarty	6·7	0	2·8	1·7	0	0	3·3	1·7	1·7	1·7	1·7	0	—	—	—
Berriedale	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Brochel Castle	—	—	—	—	16·7	20·6	8·3	8·3	2·8	3·3	—	—	—	—	—

— indicates no record

APPENDIX TABLE 5

1963

Name of Station	23/2	2/3	9/3	16/3	23/3	30/3	6/4	13/4	20/4	27/4	4/5	11/5	18/5	25/5	1/6
Goswick & Cheswick .	12·0	0	5·4	0	6·4	3·2	2·3	7·0	1·6	2·6	0	0	0	0·8	0
Boddin . . .	—	—	25·0	44·4	0	12·0	10·5	11·4	24·0	23·0	5·2	18·2	3·2	6·8	7·0
Rossie . . .	—	—	0	0	0	0	0	0	0	1·4	0	0	0	0	0
Watermouth . .	—	—	—	—	—	0	12·5	—	0	0	0	0	0	0	0
Charleton . . .	—	—	—	0	—	5·0	0	—	0	18·2	0	0	0	0	0
Woodston, Fly . .	—	—	0	0	0	0	0	0	0	0	0	0	0	0	0
Woodston, Bag . .	—	—	—	0	0	3·6	0	0	0	0	0	0	0	0	0
Rockhall . . .	—	—	22·2	9·1	20·0	13·9	10·0	0	3·6	5·6	6·1	3·5	4·9	—	4·1
Johnshaven . .	—	—	0	0	0	15·0	—	0	0	3·3	0	2·9	0	0	0
Cruden Bay . .	—	—	83·4	83·4	61·1	37·5	6·4	40·4	40·6	38·8	28·0	65·4	22·3	35·0	28·6
Ugie, Buchanhaven .	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Gardenstown . .	—	—	0	0	6·8	0	4·2	0	3·7	6·3	8·2	0	2·8	6·2	1·3
Nairn . . .	—	—	0	0	8·0	0	2·2	2·2	2·2	4·4	4·4	2·2	2·2	0	0
East Delnies . .	—	—	0	0	0	4·0	58·0	0	5·0	20·0	12·5	12·5	6·7	6·7	2·2
West Delnies . .	—	—	—	—	0	0	5·7	14·3	8·9	22·8	10·0	2·2	2·2	2·2	5·6
Cromarty . .	—	—	—	—	—	—	—	—	—	0	0	0	0	0	0

— indicates no record

APPENDIX TABLE 5, 1965——*continued*

Name of Station	8/6	15/6	22/6	29/6	6/7	13/7	20/7	27/7	3/8	10/8	17/8	24/8	31/8	7/9
Goswick & Cheswick . .	0	0	1·5	0	1·6	0·9	0	0	0·6	0	0	0	0	—
Boddin	10·9	4·1	6·6	8·4	3·3	0·8	0·8	0	0	0	0	0	—	—
Rossie	0	0	0	0	0	0	0	0	0	0	0	0	—	—
Watermouth . . .	0	0	0	0	0	0	0	0	0	0	0	0	—	—
Charleton	1·3	0	0	0	0	0	0	0	0	0	0	0	—	—
Woodston, Fly . . .	0	0	0	0	0	0	0	0	0	0	0	0	—	—
Woodston, Bag . . .	0	0	0	0	0	0	0	0	0	0	0	0	—	—
Rockhall	0	0	1·7	1·8	0·9	0	0	0	0	0	0	0	—	—
Johnshaven . . .	0	0	0	0	0	0	0	0	0	0	0	2·4	—	—
Cruden Bay . . .	18·6	48·2	28·6	23·2	24·3	30·0	34·4	44·3	27·2	32·2	22·8	22·8	23·8	17·2
Ugie, Buchanhaven . .	18·2	15·0	8·0	80·0	36·0	48·0	60·0	40·0	46·6	60·0	46·6	50·0	22·2	46·6
Gardenstown . . .	1·1	1·1	0	0	0	0	0	0	0	0	0	0	—	—
Nairn	0	0	0	0	0	0	0	0	2·5	2·5	2·5	5·0	—	—
East Delnies . . .	3·7	2·2	4·4	0	6·7	2·5	0	2·2	0	4·4	11·4	30·0	—	—
West Delnies . . .	0	0	0	0	0	0	0	0	0	2·2	13·3	44·4	—	—
Cromarty . . .	0	0	0	0	0	0	0	0	0	0	0	0	—	—

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